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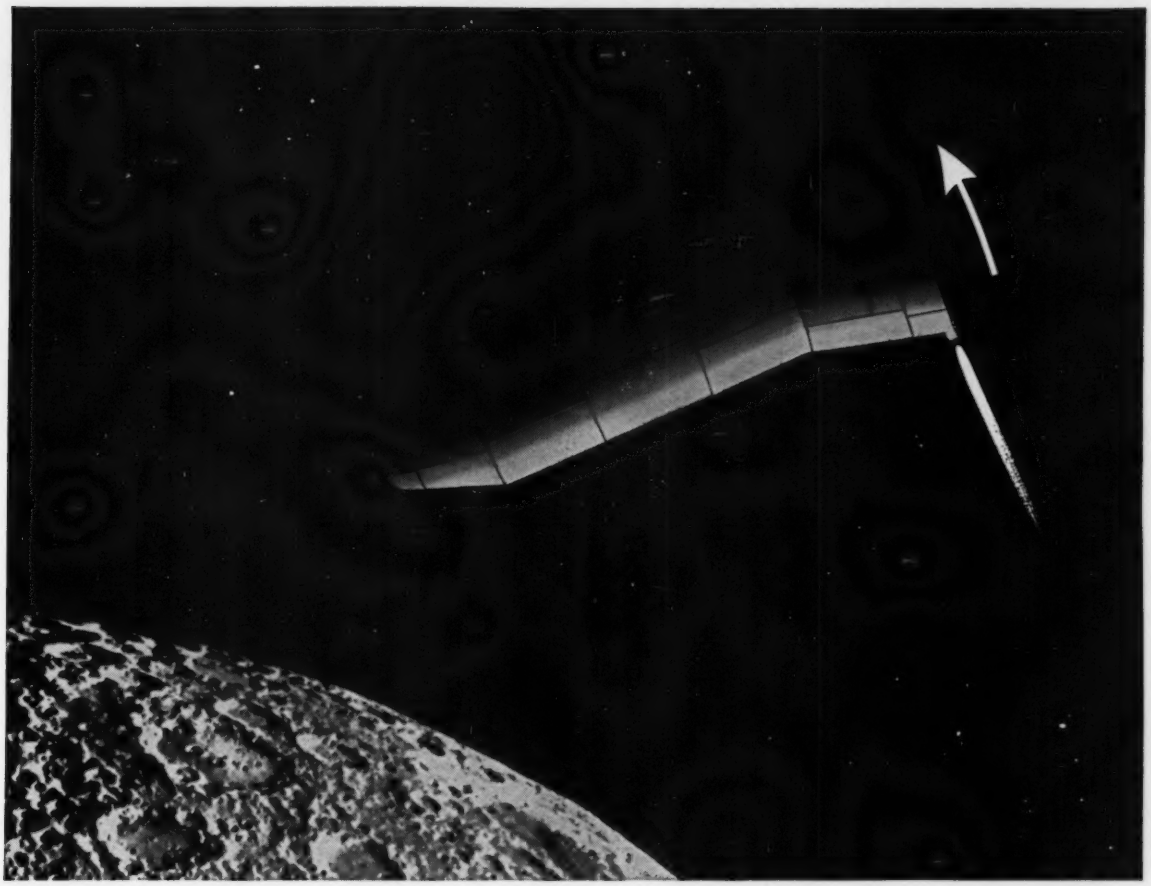

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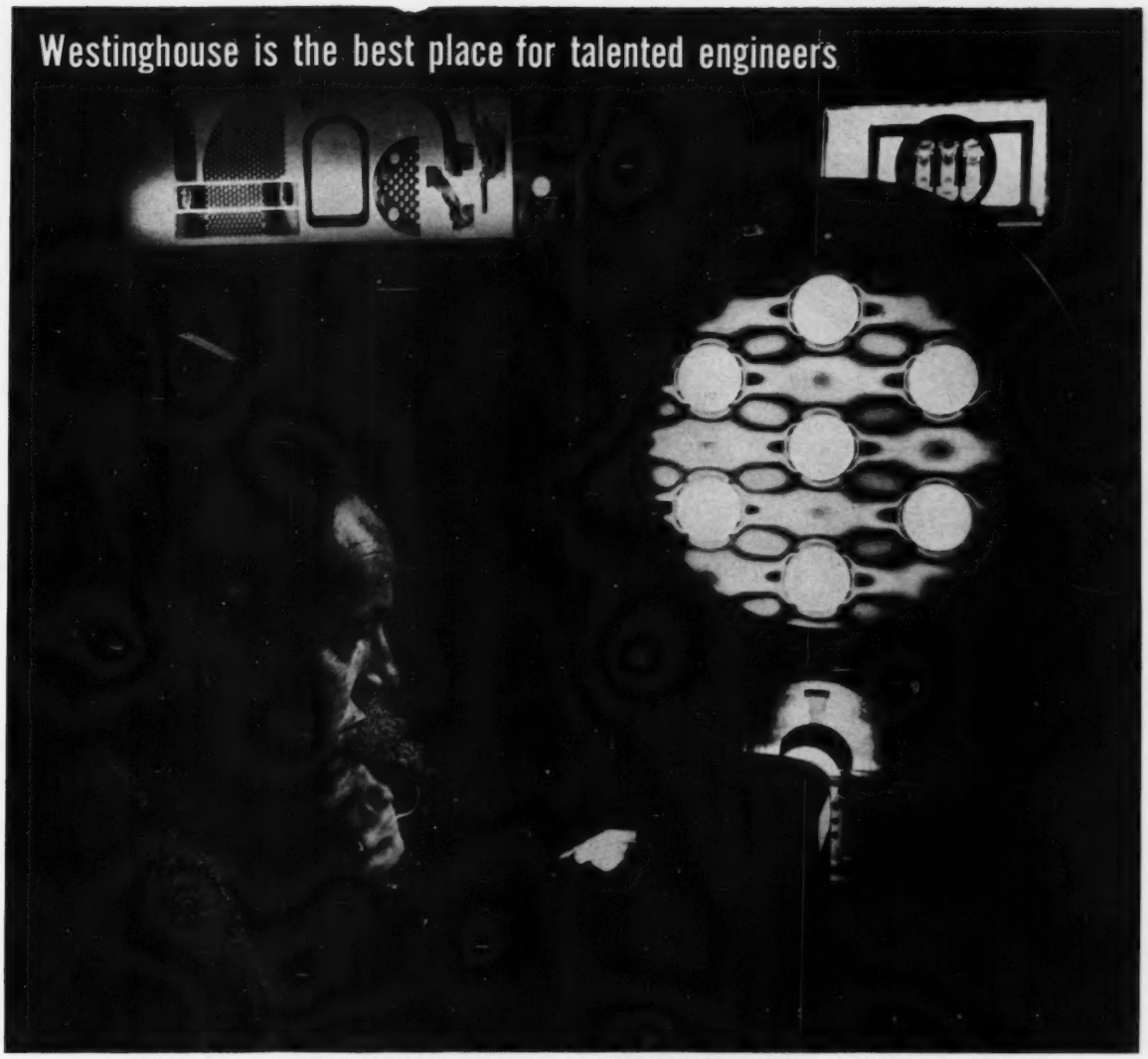

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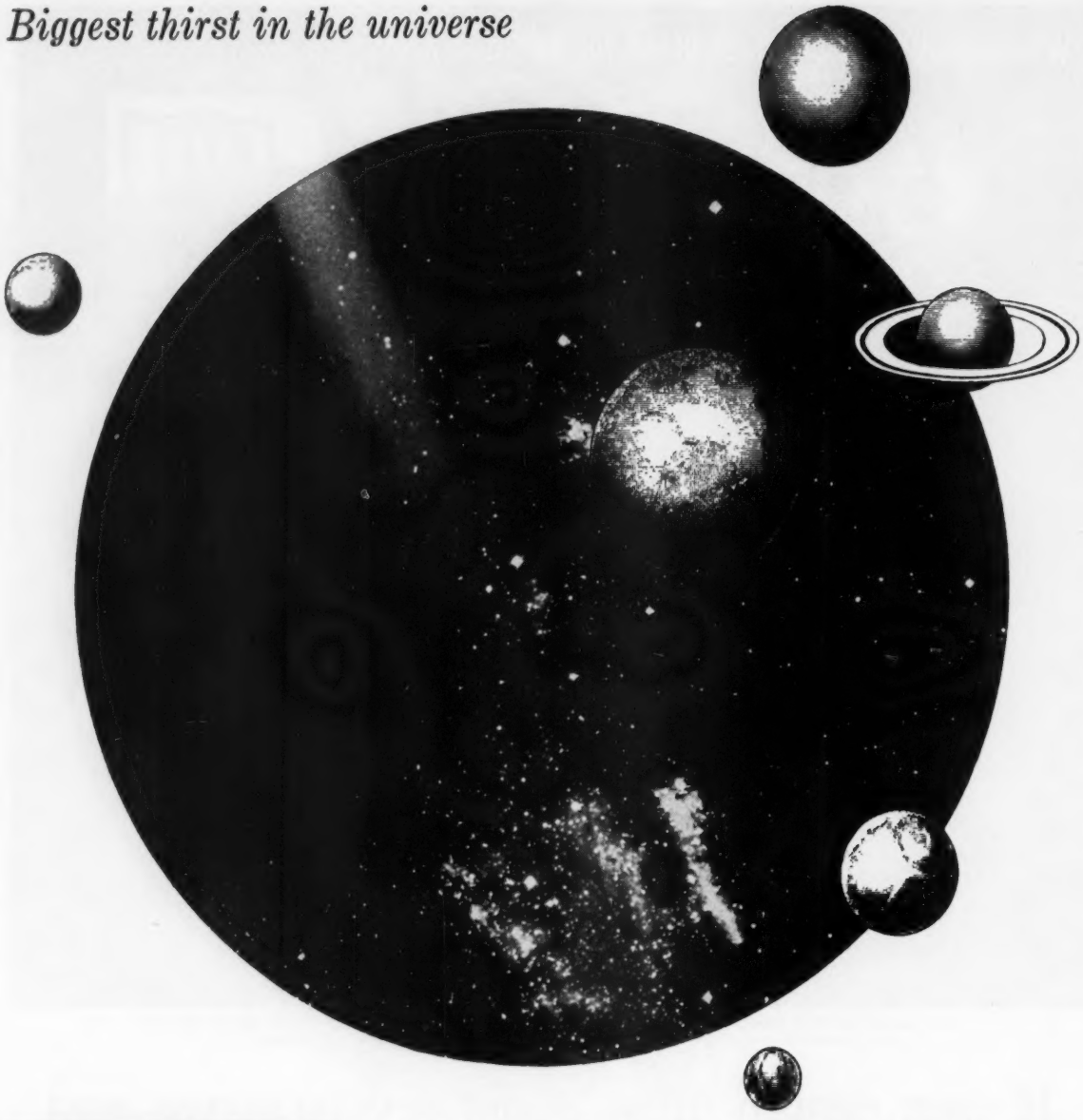

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Editorial . . .

Meeting the Objectives of Engineering Education

For almost 100 years, Cornell University's stated objective has been to provide "an institution where any person can find instruction in any study." The large number of courses offered at the University provide one indication of the extent to which Ezra Cornell's dream has been realized. But in no school of the University is the number of courses available a final indication of its educational competence.

Restating Cornell's Goal

Professor H. G. Booker, director of the School of Electrical Engineering, when speaking of the goals of a University in the January CORNELL ENGINEER, stated that its objective is "to take in good brains from high school and make these brains function as well as possible." Here is a clearer idea of the meaning of Mr. Cornell's phrase "instruction in any study." Applied to the University's College of Engineering, it can explain why a Cornell engineering graduate taking the same courses as graduates of many other engineering schools proves better able to meet the demands of the industrial world.

There appears to be little disagreement among the faculty and students with the objective Professor Booker has stated. But the gap between the theory and its application proves so formidable that few are willing to cross it. Fortunately there are several faculty and student organizations making significant studies of the implications of such an objective, but most engineering students, upon a close examination of their required courses of study, will find that the age of enlightenment is still in the distant future.

Engineering—a Means to An End

According to Professor Booker, engineering studies are a means to his objective; thus the purpose of engineering courses is not to teach students an impressive number of chemical formulas, the characteristics of selected electron tubes, or the relative merits of various building materials. It is to teach disciplines, methods of thought, and techniques of analysis to be used as a starting point for the student's own independent thought and investigation.

These should be the goals of every course in the College of Engineering and the direction in which the curriculum of each school should lead. But when the question of putting such principles into practice arises, something goes wrong. Each faculty member agrees with the program's broad objective, is convinced that his school is following them, and is certain that the courses he teaches are the best illustration of that fact. If he is right, those of us who have been concerned about curriculum revision have been worrying needlessly. Unfortunately it is this lack of objectivity among many individuals that is one of the most serious problems to be overcome.

Curricula Needs Revision

If we are willing to accept this broad objective of education on a college-wide level, does it not follow that there should be certain similarities in the curricula of each school? The disparity between everything from number of credit hours to organization of electives in the various schools seems to indicate anything but a common educational goal. What it leads us to conclude is that each school is trying to fill students with as many facts as possible. Such a program conflicts directly with any hope of aiming the curricula at improving students' ability to use their brains.

We firmly believe that the curriculum of every school can be designed with certain parallel studies. Is the chemical engineer better educated because of his heavier load of chemistry in the freshman year, or are fifth year projects any more necessary for mechanical engineers than for civil engineers? Surely the program of technical and non-technical electives does not play such a different role in each curriculum to justify the nonuniform requirements we find throughout the College.

Steps Toward Improvement

There is some very deep soul-searching necessary in every school to correct these inconsistencies. We look to the Dean's office for the clear policy statements required to bring about the college-wide changes that must be initiated. We hope for some definite action, instead of indulgent head nodding, in the formation of a much tighter curriculum with less emphasis on fact and more stress on technique.

Moreover there is an urgent need to recognize that the quantity of credit hours a graduating engineer amasses is not always the best indication of a well trained student. A revised program must recognize the importance of allowing students more time for independent thought and general participation in the non-credit aspects of the Cornell community. Here there is always the objection that students will tend to do as little work as possible. Undoubtedly many will, but a course of study catering to the lowest common denominator will produce engineers of corresponding calibre.

We have been pleased to note the beginning of some improvements, but when we see electrical engineers pouring molten metal into crumbling sand molds, and engineering physics students spending valuable time machining taper plugs, we are convinced that a more vigorous shake-up is needed at once. Let us hope that a liberal engineering faculty will soon take the required action. A.S.R.

Founded in 1885

THE CORNELL engineer

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The sun, whose corona is pictured on the cover, has long been the subject of scientific study. Please see articles on pp. 15–21.

Published monthly—October to May—by the CORNELL ENGINEER, Inc., Carpenter Hall, Ithaca, N. Y. Edited by the undergraduates of the College of Engineering, Cornell University. Second class postage paid at Ithaca, N.Y., under Section 103, Act of October 3, 1917.

Subscription per year: regular $2.00; with membership in the Cornell Society of Engineers, $3.00; students and faculty, $1.50; single copy, $.25 on campus; $.35 elsewhere.

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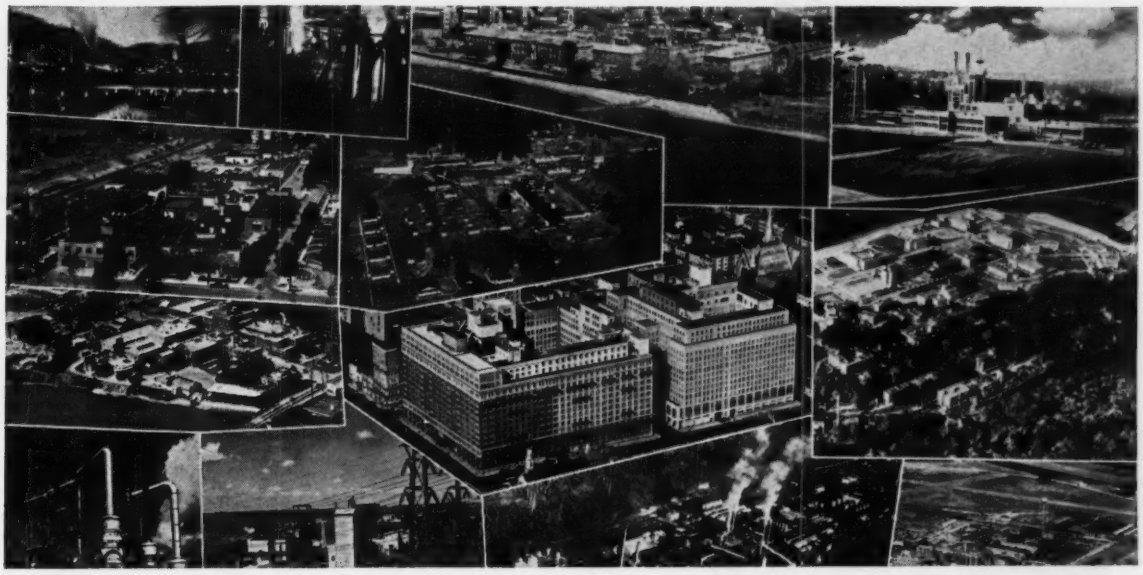

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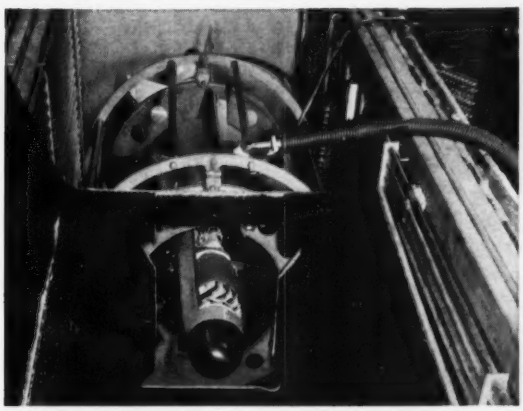

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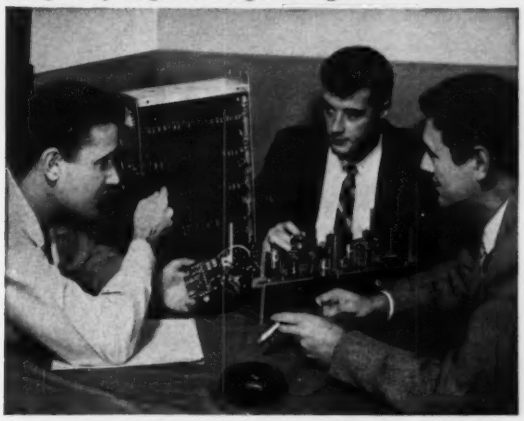

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ESCHATOLOGY AND ASTRONOMY

by Norman S. Atwood, Jr., EE '63

Prophecy has always been a popular occupation with mankind. But until recently, there has been no factual foundation for predictions of the future. The prophecies of the ancient Oracles of Delphi were accepted without question, but in this age of analysis the approach is usually a scientific one, with logical reasoning and technical facts supporting the conclusion. Hence, Delphi has been replaced by the observatories such as Palomar and Mount Wilson, which supply astronomical information relevant to the age-old questions of the significance and destiny of man in the universe.

Traditionally, the solution of these questions have been left in the hands of theologians, who have even given the subject a formal title: eschatology, the study of the ultimate destiny of man and the world. But due to the great advances of scientific knowledge these days, the scientists now have their fingers in the pie also.

However, scientific predictions are subject to some limitations. Intelligent life, by its ever-increasing control over nature, can alter to a significant extent the development of the future and cause it to conform to its own purpose. This uncertainty of evolutionary development imposed by intelligence is nevertheless negligible in the areas of natural phenomena over which man has no control. In these areas science may predict the future with confidence from natural laws.

The extraterrestrial universe is a realm in which man's domination will in all probability forever be of minute consequence. When the limited extent of man's domain is compared with the vast reaches of space, it is evident that the cosmic order will remain relatively unchanged, even if man chooses to completely destroy the earth. But while the earth's destiny may depend on man, man's destiny likewise depends on that of the earth. And the earth's destiny mainly depends on the evolutionary processes of the universe.

The Contribution of Astronomy

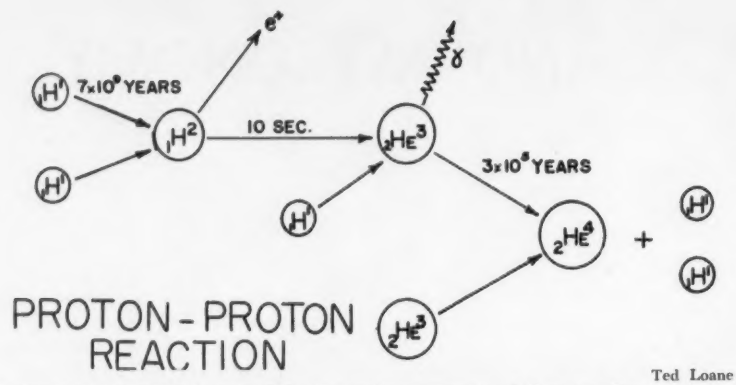
In science's prophecy of the future, the contribution of astronomy is the determination of the earth's probable future due to the action of cosmic forces. Specifically, it seeks to discover what the prospects are of the earth's continuing as man's abode, and to study the probabilities of events which could end the existence of mankind.

What is the nature of these cosmic events which would, either directly by their own action, or indirectly by their influence on terrestrial actions, alter the delicate conditions which sustain life on earth? Two types of such cosmic disasters are conceivable: first, a collision or a close encounter between the earth and another celestial body, thus disrupting the earth with earthquakes, volcanic eruptions, tidal waves, or the loss of its atmosphere, or perhaps even pulling the earth into a new orbit, thus varying its average temperature; second, a change in the intensity or nature of the sun's radiation received by the earth, which would occur if the sun's luminosity or temperature were to change.

These cosmic disasters have been carefully considered by astronomers, and it is now possible to make some evaluations and predictions. Every day the earth's mass is increased by several tons due to collisions with meteoric material. To a great extent, this material is in the form of fine dust and small particles which, upon entering the earth's atmosphere at velocities of approximately 30 miles per second, are immediately consumed by friction. Larger meteorites, weighing up to about 200 pounds, may strike the earth 5 or 6 times a day. But

Earth's mass is increased by several tons every day by collisions with meteoric material. Most are consumed by friction when they enter the atmosphere, but heavier ones penetrate making craters like the Arizona Crater above.

Spiral nebula in Andromeda is one of many which astronomers study. Their studies provide positive evidence that the chances of a cosmological disaster involving the earth are slim.



Ted Loane

Proton-proton reaction is one of the two primary sources of thermonuclear energy in the sun. In the above diagram, only nuclei are shown, since at the temperature at which the reactions occur, atoms are stripped of their planetary electrons. The times noted are for conditions prevailing in the interior of the star.

this material poses no threat to human life, when the probability of one's hitting a populated area is considered.

But larger masses also hit the earth. Twice in the present century meteorite falls of several hundred tons have occurred; fortunately both times in unpopulated areas of Siberia.

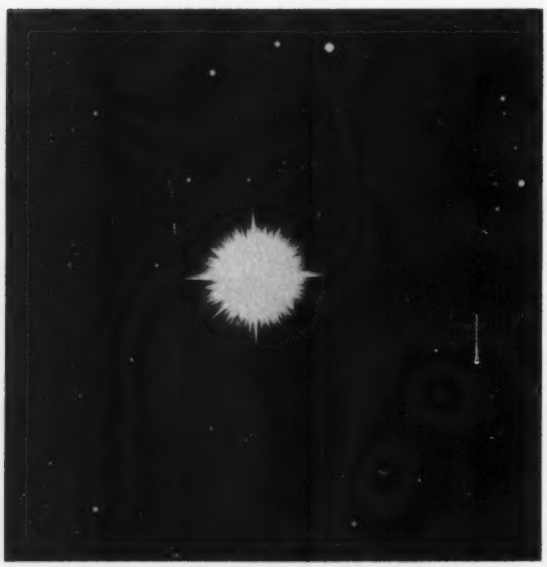
As for the chances of the earth's colliding with a really large body, they are relatively insignificant. Within the past few years, approximately a dozen asteroids have been discovered whose orbits cross that of the earth. It has been estimated that a direct hit by one of them would occur about once in 30 million years. If there exist several hundred of these asteroids, which is more likely, the estimate is once every 2 million years. But even a collision with an asteroid whose mass is comparable to that of a mountain would not be a total disaster. A body a quarter of a mile in diameter would create a crater perhaps 25 miles across, and devastate an area about the size of Texas. This is the worst which could happen, since the orbits of all bodies larger than this are known, and none comes near that of the earth.

The above information takes care of bodies from within the solar system, but what of bodies from outer space? The probability of an encounter with a passing star which could cause the destruction of the solar system has been computed. It has been found that even among the hundreds of billions of stars in the galaxy, only one or two such encounters would have occurred in the 3 billion years believed to be the galaxy's age.

Another possibility in this type of disaster is the disintegration of the moon, resulting in a rain of huge pieces upon the earth, leaving it dead and pock-marked like its late satellite. This event could actually occur. Effects of tidal friction on the earth-moon system have been calculated. If the loss of energy through tidal friction continues at the present rate, the month, the earth's sidereal day[1], and the mean lunar distance will increase. The maximum will occur when the sidereal day and the month are equal. After this time the effect of tidal friction will be to shorten the month and bring the moon closer. When the moon comes within a distance of about 2.4 times the earth's radius it will be torn apart by gravitational attraction, parts falling to the earth and parts going into the formation of rings like Saturn's. If this theory is correct, this should occur January first, 100,000,000,000 A.D.

Stellar Interiors

The second type of cosmic event which could affect the existence of life on earth is a change in the sun's integral properties, such as its size, luminosity, or temperature. It has been estimated that the atomic

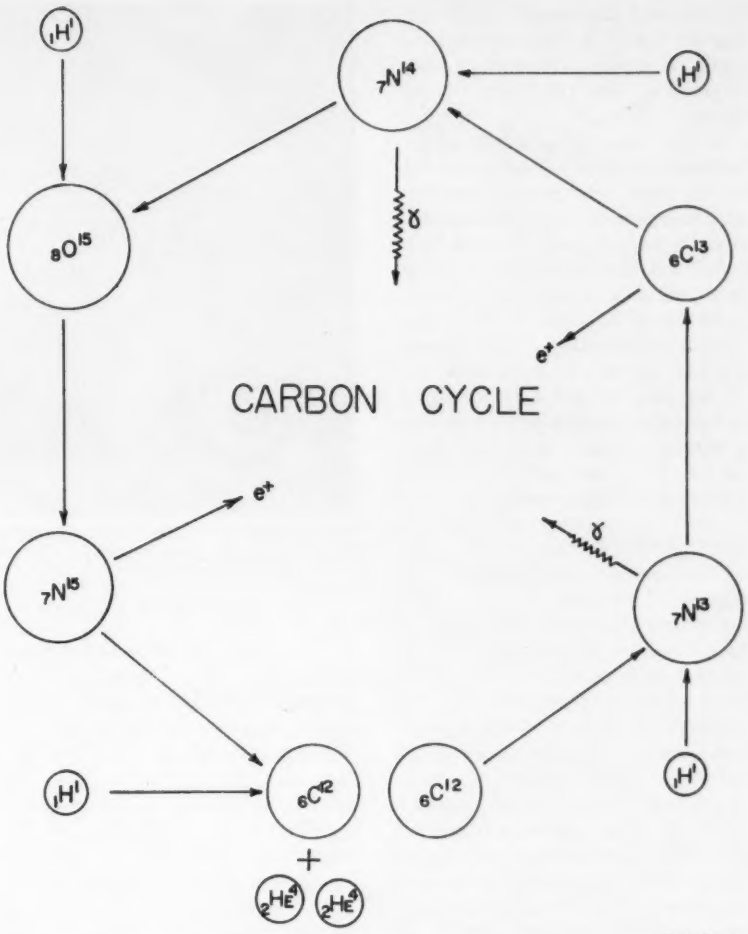


Throughout our universe it is common phenomena for a star to blast into a state whose luminosity surpasses that of its normal case by a factor of several hundred thousand. A star in this exploded state is known as a nova. Above are direct photographs of nova Hercules. The one on the left was taken March 10, 1935, the one on the right on May 6, 1935.

reactions in the interior of the sun have been sustained for roughly three billion years. How much longer the sun's thermonuclear reactions will continue to operate and what will happen when the fuel supply is exhausted are problems studied in a branch of astronomy called "stellar interiors."

According to an article by Dr. Albert G. Wilson, Director of the Lowell Observatory in Flagstaff, Arizona, a present theory of the structure of the sun represents it as a model consisting of two zones. These two zones are: 1) a core, whose temperature is sufficiently high to enable thermonuclear energy generation to take place, and 2) a cooler surrounding envelope in which no energy generation occurs. Initially, a star is composed almost entirely of hydrogen. Within the core the hydrogen is converted into helium while convection currents keep the substance thoroughly mixed. The envelope, cooler and less disturbed, remains hydrogen-rich. As long as there exists an adequate supply of hydrogen in the convection core, there is little change in the star's integral properties. Eventually, however, the hydrogen in the core becomes exhausted and within the core there no longer exists nuclear energy production. The central core becomes an extremely hot isothermal core, and at the interface between the core and the hydrogen-rich envelope, nuclear energy generation occurs in a thin shell. The isothermal core grows in mass and radius as the thermonuclear shell eats its way out through the hydrogen envelope. This process cannot continue until the shell traverses the entire envelope, but must terminate when the isothermal core acquires a mass of about twelve percent of that of the entire star. During the time of growth of the isothermal core, the star increases somewhat in luminosity, but remains constant in temperature.

Another theory has been developed by Schwarzschild and Sandage involving the evolutionary sequence which comes into operation after the twelve percent limit has been reached. According to their theory, after the isothermal core reaches the critical mass it begins to contract, and through contraction gravitational energy is released. During this phase the total luminosity of the star remains nearly constant, but the envelope becomes greatly extended. Later, when the contracting helium core reaches a much higher temperature, a thermonuclear reaction in which helium nuclei form carbon becomes operative. Then the star becomes more luminous. After this stage, the star may collapse and become what is known as a white dwarf star. These are stars whose matter is in a degenerate form. The nuclei of the atoms, devoid of their electronic shells, are pressed together, giving densities of the order of tons per cubic inch.



Ted Loane

Carbon cycle, the other primary source of energy, is similar to the proton-proton reaction, since in both processes four protons are fused to yield an alpha particle, plus energy. By means of the two reactions, 564 million tons of solar hydrogen are converted each second into 560 million tons of helium. The last four million tons are converted into radiant energy.

Observational Data and Conclusions

The above statements are theories. But some amazing agreements have been obtained between the consequences of these theories and the observational data. The rate at which a star consumes its hydrogen depends on its mass. The most massive stars burn their fuel at the highest rates and are therefore the most luminous. It follows that massive stars reach the twelve percent limit earlier than less massive ones, and start out earlier on an evolutionary track such as that proposed by the latter theory. In a large aggregate of stars, such as a globular cluster, containing stars of all masses, there should be some which are still consuming the hydrogen in their cores and some which have reached the post twelve-percent evolutionary stages. Sandage, at Mount Wilson and Palomar, has studied the luminosities and temperatures of several hundred stars in the globular clus-

ter M3, and has found that all stars heavier than 1.2 solar masses have taken off on an evolutionary track resembling that predicted by the theory.

If the universe is in the neighborhood of three billion years old, as has been determined from several independent observations, and stars down to 1.2 solar masses have consumed the hydrogen available to them, how much time remains before stars of mass 1.0 reach this critical evolutionary stage? Assuming that our sun is of the same age as the stars in M3 and is subject to the same interior processes, then it should continue to radiate more or less as in the past for another four or five billion years.

Theory predicts that in a large aggregate of stars, such as this globular star cluster in Hercules (M13), there should be some stars still consuming the hydrogen in their cores and some which have reached the post-twelve-percent evolutionary stages.

Stellar Explosions

The normal evolutionary sequence of the sun, therefore, does not pose any appreciable threat to man's existence. But what if the sun should suddenly become a nova, vaporizing the entire earth in a matter of minutes without previous warning? (As if anything could be done about it if there were such a warning!) Throughout our vast universe it is a common phenomenon for a star to blast into a state whose luminosity surpasses that of its normal state by a factor of several hundred thousand, and in extreme cases, of several billion. The star in this exploded state is known as a nova, or possibly a supernova. The "Star of Bethlehem" could have been one of these stellar explosions.

In our galaxy, the Milky Way, at least twenty stars explode yearly. Since our galaxy is about three billion years old, it follows that approximately 60 billion stars have already exploded during this period. But since there are about 100 billion stars in the Milky Way, by simple arithmetic, the sun is due to become a nova sometime in the next two billion years. Hence the chances of its exploding in the next year are only one in two billion. So although this is the most probable event mentioned here which could cause a premature termination of mankind's existence, the chances are one in two thousand of the sun becoming a nova in the next million years. No self-respecting gambler would ever bet against these odds!

Even if the reader is not a gambling man, he should now be able to sit back and relax, with a sigh of relief, and smugly contemplate the fact that the only obstacle which could deter man from fulfilling his ultimate destiny is himself. From what has been observed of cosmology, it can be predicted with conviction that man will not cease to exist because of some cosmological phenomenon before he can perfect his own method of self-destruction.

[1] sidereal—measured by the apparent motions of fixed stars; as, sidereal day, the interval between two successive transits of the first point of Ares over the upper meridian of any place, equal to 23 h. 56 min. 4.09 sec. of mean solar time.—Webster's New Collegiate Dictionary.

Close encounter with another heavenly body, like Halley's comet (shown here in 1910), could cause tidal waves, volcanic eruptions, or loss of atmosphere. Fortunately the chances of such an encounter are extremely small.

ACCOMPLISHMENTS OF IGY

by Jean Walrath, ChemE '63

To examine intelligently the accomplishments of the International Geophysical Year,[1] it is necessary first to examine its aims. What were the reasons for this intensive, eighteen-month-long period of research? Why this huge quest for basic technical knowledge which took the efforts of 60,000 people from 66 nations?

Cooperation Not New

Contrary to popular belief, the IGY of 1957–58 was not the first international research period ever held. Its precedents were the First Polar Year of 1882–3 and the Second Polar Year of 1932–3. In 1950, a request was made that the third research period be held after a 25-year interval instead of another 50-year interval. There were several reasons for this: (1) the "warehouse of basic data" that is so essential for progress in pure and applied science was empty; (2) travel at super-sonic speeds and the likelihood that in the near future man would enter space made imminent the problem of finding out more about the upper atmosphere and the earth itself; and (3) a period of unusual activity on the sun was predicted for 1957–8.

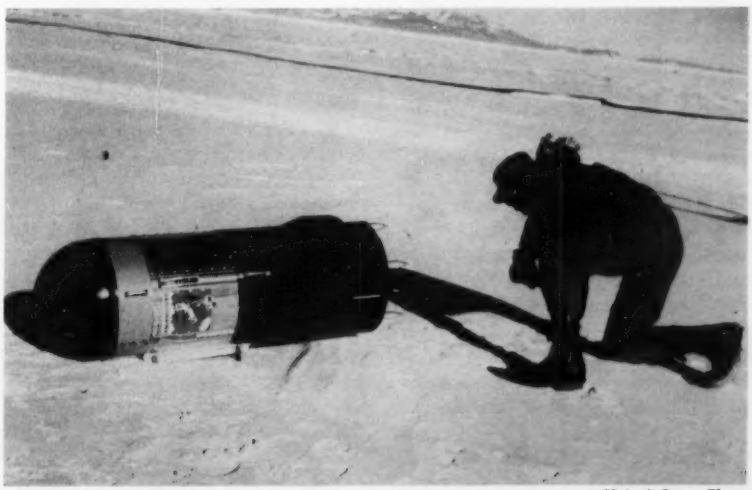
Overall plan for IGY was broken down into three areas of study. The first of these included studies of the earth itself; the second took in studies of weather and climate; the third covered the upper atmosphere and outer space. Simultaneous observations of geophysical phenomena from all over the earth was a necessary condition of accurate investigation. Therefore international cooperation was made an integral part of IGY. This cooperation between nations might be considered one of the main accomplishments of the project.

Intense Polar Study

During IGY, the most intensive investigation yet made of Antarctica was undertaken. Twelve nations joined in the effort to learn more about the true character of this mysterious continent. It was found that beneath the ice sheet lie many mountainous islands, most of which would be below the ocean's surface if the ice masses were to melt. Another discovery, which is still controversial, is that there may be a major separation between east and west parts of the continent. Investigators also found that because the quantity of ice in Antarctica is much larger than was previously believed, the total of the world's ice and snow is 40 percent greater than formerly estimated. Extensiveness of the investigations and scattered locations of the outposts maintained by the different nations permitted the first accurate weather census to be taken in the area.

This will help immensely in determining what bearing Antarctica has on the weather in the rest of the world. The lowest temperatures ever recorded, -125F at the Soviet outpost, Sovietskaya and -135.4F, in a balloon twelve miles over the South Pole, were reported.

But Antarctica was not the only cold region in the world which was



United Press Photo

Portable weather stations, called "grasshoppers", were used to transmit weather information to a central weather headquarters at McMurdo Sound, Antarctica. These fully automatic units were dropped by parachute into remote areas of the Antarctic, where they commenced to sprout legs, antennas and anemometers, and began sending out weather information.

United Press Photo

Weather balloon is launched by Air Force. This balloon is twelve feet in diameter and carries a 500-pound gondola equipped with high-altitude weather equipment. Other balloons sometimes carry photographic equipment for taking pictures of earth, sun, and stars.

studied thoroughly; glacier research was done in the Brooks Range, the northernmost mountains on the North American continent. There it was learned that glaciers grow fastest in the summer. This is in agreement with the argument that humidity is much more important than cold in making an ice age, because summer winds over this range are moist, while winter winds, coming from the frozen Arctic Ocean, are dry. An enlargement of this phenomenon is thought by some to be the cause of the successive ice ages of the past million years. When the Arctic Ocean is free of ice, the winds proceeding from it are moisture-laden and cause the formation of the continental ice sheets; when it is frozen over, the winds are dry and the growth of the ice sheets is halted.

To study the drift paths of ice and the surface currents in the Arctic Ocean, both the United States and Russia maintained research stations on ice islands. Each country manned thin ice floes, sometimes only seven feet thick, in addition to rather large, thick islands. The research done in this field enabled the drift paths of ice to be charted anew, thus diminishing, for the present, the hazard of this ever-present menace to shipping.

Aurora Linked to Van Allen Belt

One of the most startling events of IGY was the discovery of the Van Allen radiation belt, named after its discoverer, Dr. James A. Van Allen, of the University of Iowa. This belt of very high radiation encircles the earth within the earth's magnetic field, at a height of 1,000 to 3,000 miles. Its presence helps explain such phenomena as the aurora, and it must be taken into account when plans for space travel are formulated. In addition to this belt, a second radiation belt at an altitude of 10,000 miles was discovered by Pioneer III, one of the U.S. cosmic rockets.

The aurora itself, a phenomenon which has puzzled man for many centuries, was the subject of much IGY research. Auroras have their origin in the ionized, upper layers of the atmosphere. It is now thought that these "curtains" of light may be caused by charged particles issuing from the sun. Most of these particles are caught in the earth's magnetic field, where they form the Van Allen Radiation Belt. However, some escape at the magnetic poles, where the lines of force are weakest. These particles, colliding with other particles in the earth's upper atmosphere, are believed to cause the aurora.

Many new discoveries were made during IGY about the earth's atmosphere. One was the "electrojet", an electrical current circling the planet high in the atmosphere. This current and currents circling the earth's poles are believed to be the cause of changes in the earth's magnetic field.

IGY Satellites

Artificial moons were the most publicized of IGY events. By the end of IGY, seven artificial moons had been orbited, four of these by the United States and three by the Soviet Union. Although the United States led in number of rockets orbited, it was far behind Russia in payload. For instance, Sputnik III had a payload of 2,925 pounds; the payload of Explorer IV was 25.7 pounds. These satellites detected the existence of the radiation belts and made a surprising discovery about the shape of the Earth. The latter event came about after a

study of the Vanguard rocket's orbit, which seemed at first to be wobbly. It was found that what seemed to be an imperfection in its orbit was actually due to the fact that the earth is pear-shaped, the bottom of the pear being in the southern hemisphere.

Cosmic Rays

The origin and effects of the cosmic rays which strike the earth's atmosphere with such force that they penetrate deep into the earth was another puzzle which IGY attempted to solve. The correlation between cosmic rays and solar flares, which are vast eruptions on the sun, was studied. It was believed that the sun was the source of cosmic rays. Data obtained from monitoring auroral activity by means of cameras and radar seem to support this theory. Still to be processed are mountains of data obtained from the constant watch kept on the sun by thirty-three countries during the IGY. Any ultimate conclusion about the source of these rays will be some time in coming.

Cosmic rays provide a means of indirectly studying the shape of the earth's magnetic field and its changes in relation to events on the sun. This is possible because cosmic rays are deflected by the field according to their energies, with the rays of greatest intensity being deflected the most. The different compositions and intensities of the rays at different times can therefore be used to study the magnetic field and its changes. To measure these rays, ice-breakers in polar regions, satellites, balloons, high-flying rockets, and aircraft were put to use. Their efforts will greatly increase man's understanding of the earth's magnetic field and its bearing on other phenomena.

The solar rays which are the suspected sources of cosmic rays have yet another effect on the earth. Dr. Walter Orr Roberts, who headed the United States IGY program of solar studies, believes that the research in this field has established a relationship between solar flares and changes in weather patterns at the highest level of IGY weather mapping. This relationship, if confirmed, would mean that during the eleven-year cycle of sunspot maximum and minimum, the earth's weather would follow a predictable change.

Oceanic Discoveries

The oceans of the earth were subjected to their most extensive investigation during IGY. Three-hundred fifty tide-gage stations and 80 research vessels took part in oceanographic research. Sea level changes and oceanic water budget were studied. Ocean currents were also studied, and several new discoveries were made in this field. Three major counter-currents were discovered and measured. One of these is in the Atlantic Ocean, flowing deep beneath the Gulf Stream. The other two are in the Pacific. The Pacific current lying closest to the surface is the largest of the three currents. It was traced for 3,500 miles, but its actual length may be twice that distance. It lies from 100 to 800 feet below the surface and has been compared in magnitude to "a thousand Mississippi's." It flows at three times the speed of the surface current.

The discovery of deep trenches off the coast of South America and in the Arctic basin has also increased our knowledge of the oceans' anatomy. In the Pacific, a vast region abundant in manganese, iron, cobalt, and copper of potentially great value, was found. These deposits are so rich that their exploitation may not be very far in the future.

These have been the discoveries made, the theories formulated or substantiated. There is still much data to be analyzed and evaluated. This task will take many years. In the meantime, the International Geophysical Year is still continuing in several smaller ways: a concentrated study of the Indian Ocean by the countries bordering on that body of water is planned for 1961–2, and post-IGY committees, such as the Special Committee for Inter-Union Cooperation in Geophysics are now in existence. Let us hope that the IGY has set a pattern for international research which will be continued in the future.

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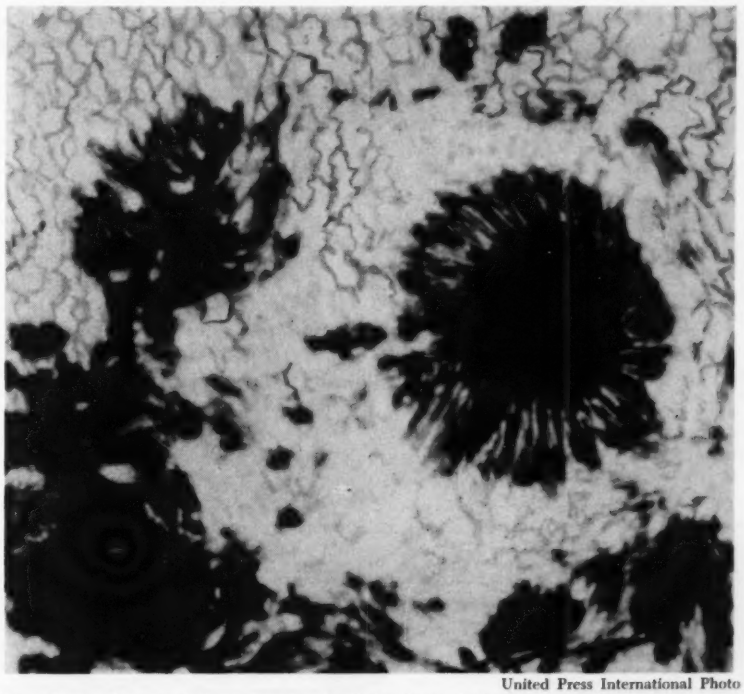
[1] See CORNELL ENGINEER, Vol. 23, No. 2, (November, 1957).



United Press International Photo

One of the clearest pictures ever made of the face of the sun, this closeup shows the sunspots (black areas) believed to be the cause of electrical disturbances on earth. Areas are about 9000° Fahrenheit, and about 30,000 miles in diameter.

New Developments in the Control of Thermonuclear Power Bring Us Closer to Obtaining . . .

POWER FROM FUSION

by Robert A. Stern, EE '63

Ever since Hahn and Strassman discovered uranium fission, man has wished he could control the great forces which are hidden in the atom. This ambition was realized when Enrico Fermi, at the University of Chicago in 1942, produced the world's first self-sustaining, controlled chain reaction.

Fission is a phenomenon which takes place every day in certain materials which are said to be radioactive; that is, they emit particles. The particles include alpha and beta particles, and gamma rays which are dangerous due to their high penetrating power and effect on tissues. Fission reactions need no push and cannot be slowed down. Radioactive elements can be natural or man-made. When subjected to the bombardment of the particles from a radioactive element, a stable element becomes radioactive. These radio isotopes can be used benficially in medicine, agriculture, and industry.

The atom bomb demonstrated the immense amounts of power which could be derived from uncontrolled reaction. The chain reaction is produced by bringing two chunks of radioactive material (usually U-235 or Pu-239) together quickly. Neutrons which are emitted by the uranium or plutonium strike other atoms. Since the neutron is uncharged, it penetrates the field of electrons surrounding the atom and hits the central nucleus. When a neutron hits the nucleus, the nucleus becomes unstable and splits apart into two roughly equal halves, meanwhile emitting more neutrons and particles. The neutrons in turn hit other atoms and cause them to split. The sum of the weights of the reactants and the products of the reaction are not equal. Some mass is lost. From the famous Einstein equation, $E=mc^2$, which says that matter and energy are interchangeable, it is shown that the small loss in mass during the chain reaction is converted into energy. The large amounts of energy liberated can be accounted for because "c" in the equation is the speed of light in centimeters per second.

Power from Fission

If a chain reaction could be controlled, it could be used. Direct tapping of power from a nuclear reaction in the form of electricity is difficult, so an intermediate method had to be found. A heat exchange device which can transport heat from one place to another can be used to harness the energy of the atomic reactor. The heat generated from the reactions is used to heat water and make steam to drive a turbine and produce electricity. But use of the cooling water from the reactor is dangerous because the water itself can become radioactive and harmful to human life, so a second heat exchanger is used in conjunction with the first. The steam generated from this second exchanger is safe to use.

Many other uses of atomic power are possible; automobiles, ships, trains, and planes could be powered by fission reactors but for one important fact. Since the fuel used in a reactor is radioactive, it emits particles and rays which can cause damage to human cells. The alpha and beta particles are easy to stop, but gamma rays will penetrate several feet of lead. This shielding is necessary to protect the users of atomic engines, and this is the drawback; the shielding for only a small amount of radioactive material weighs several tons. Planes would be very heavy and cars would have to be very long in order to separate the reactor from the passengers. Because of their unwieldiness, reactors have, for the most part, been used on land in

Ted Loane

Kink type of instability causes the plasma to hit the walls of the tube and contaminate the pinch.

Ted Loane

"Sausage" instability in a linear pinch constricts plasma.

the form of power stations. Notable exceptions are the Navy's atomic submarines which can cruise more than 50,000 miles without refueling. In the future, with new shielding processes and other advances, it is hoped, man will attain complete control of fission.

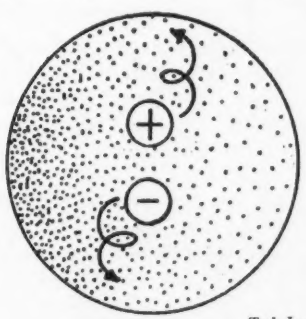
As man looked forward to an age of the atom, another discovery in the field of atomics was made. In 1952, just after the Korean War, the United States exploded a hydrogen bomb. Fusion, the process of joining two light elements to make a new heavier one, had been known of for a long time. It takes place in the sun and had been produced on earth with large particle accelerators which fling particles at each other at enormous speeds and energies.

Previously, it was known that the tendency towards fission decreased as the atomic weight of an element decreased. What did those elements of low atomic weight tend to do?—They fused. Hydrogen, helium, and lithium, all found on the sun are the three lightest elements. By bombarding light elements such as lithium with hydrogen nuclei (protons), scientists created two helium atoms. This reaction is represented by the equation

$$_1H^1 + {}_3Li^7 - {}_2He^4 + {}_2He^4$$

But this reaction required millions of electron volts. Fusion can also be produced by pressure and high temperatures. By using an A-bomb trigger to create temperatures of millions of degrees, a fusion reaction can be touched off.

Fusion is known to take place on the sun in the form of the carbon cycle. Now fusion could be produced on the earth. Farseeing men immediately set out to harness



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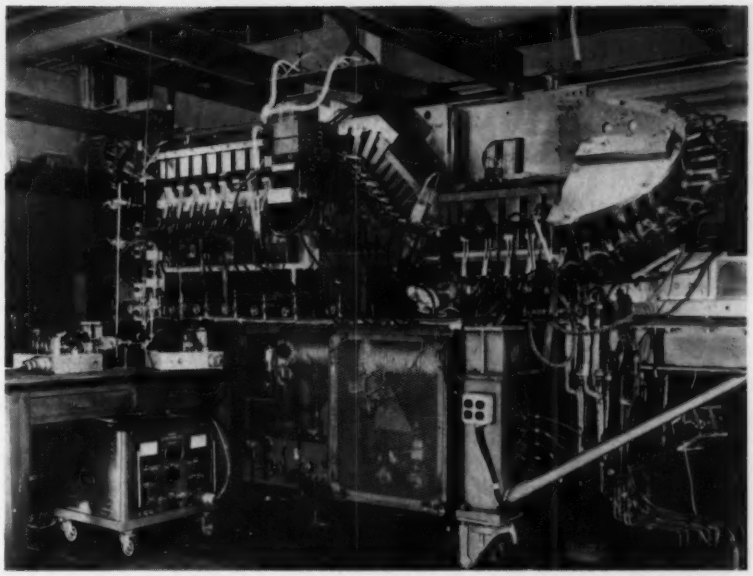
Cross-section of tube showing separation of particles due to unequal magnetic field near inner side of tube. Dots are cross-sections of magnetic lines.



"B3" research stellerator, being used at the James Forrestall Research Center at Princeton University, employs a method called magnetic pumping to heat the gas beyond one million degrees.

fusion too, for the supply of hydrogen and its isotopes is as plentiful as the water in the ocean. Fusion being the opposite of fission, the weight of the elements produced is greater than the individual weights of the reactants. However, as in fission the total weights do not agree, and mass is again lost as energy is released. Just as neutrons must penetrate the electron field and nucleus of a uranium atom to cause fission, light atoms must come close together to produce fusion. The atoms, when heated to high temperatures or bombarded by other particles, become stripped of their electron shells and the free nuclei come together and fuse.

Controlling the Reaction

If harnessing fission for power was difficult, controlling fusion appeared to be impossible. Fusion occurs within a temperature range of over one million degrees to one hundred million degrees absolute. At such high temperatures, there is no substance which can contain hot gases. Consequently, some other sort of containment must be found to enclose the fuel gas. Probably, for this reason, the hydrogen bomb was first used in the form of a weapon instead of in a useful, peaceful situation. The comparison between fission and fusion is clear—in fission, the reaction occurs at relatively low temperatures, the weight of the products is less than the original element, and the reaction is contained in an atomic pile. Fusion results in heavier particles being created, occurs at extremely high temperatures, and cannot be contained in any solid container. Furthermore, although the energy released per fission is greater than the energy released per fusion of atoms, the fusion reaction releases about eight times as much energy per pound as does the fission reaction. This is due to the fact that there are a great many more atoms in a pound of hydrogen or helium than in a pound of uranium. Finally, both methods can use a heat exchanger to draw off the energy generated.

The main problems which must be solved in order to use fusion for power generation can be summarized as (1) containing the gas (actually plasma, because the atoms are stripped of their electrons), (2) heating the gas to fusion temperatures, (3) confining the plasma for a long enough time for fusion to begin, and (4) obtaining power from the reactions.

The problem of confining the plasma has been approached in a number of ways. The main methods rely on the so-called "pinch effect", and the use of magnetic

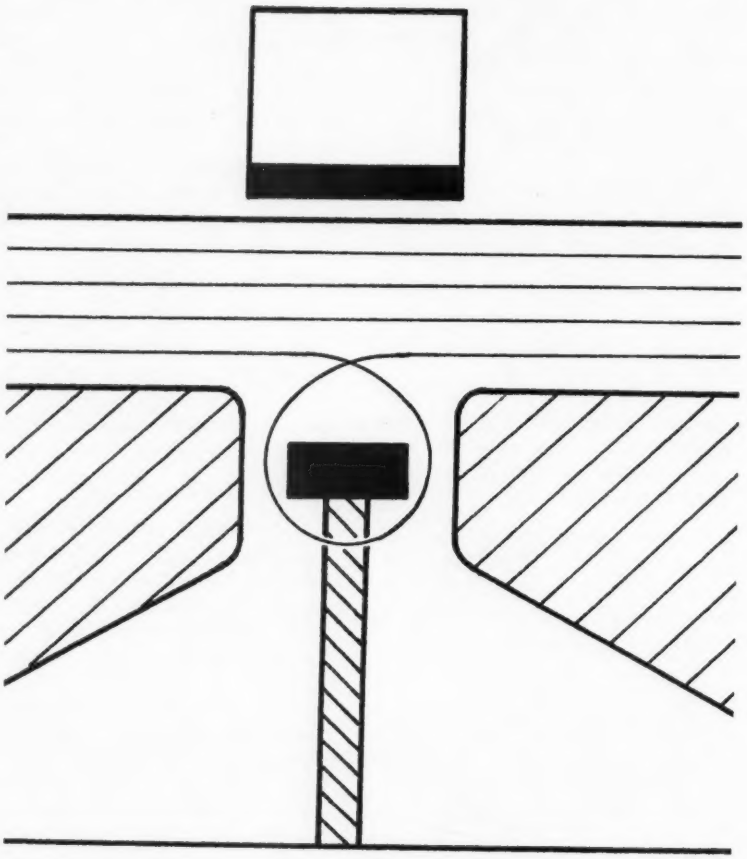
fields. The pinch effect is so named because of the fact that when a high current is passed through an ionized gas, the current causes the plasma to contract toward the center of the tube containing it. This is due to the magnetic effect set up by the current. When the plasma is pulled to the center of the tube, its density increases and compression results which causes heating. Compression of this type, which occurs in the neon display sign, may result in temperatures of one million degrees when sufficient energy is passed through the tube. The magnetic field container makes use of the transformer or Faraday effect. When the flux through one circuit changes, it produces similar changes in the flux of an associated circuit. In the case of plasma confinement, coils of wire are wound around a tube or toroid and current is applied to them. The plasma inside the tube acts as the secondary of the "transformer," and is made to contract by the magnetic field created inside the tube. A side effect of this contraction is ohmic heating due to the I^2R losses in the plasma which, although ionized, is not a perfect conductor. Other devices similar to the magnetic "bottle," as it is called, are the magnetic mirror machine, which uses a magnetic field to repel ions of either sign from two directions to compress and heat them, and a device that uses a rapidly rising magnetic field to contain and heat the plasma.

Heating the Plasma

The two devices now used to heat the plasma are based on the pinch effect and the magnetic field effects. Pinching, as stated before, constricts the plasma toward in the center of the tube and in the same process, heats it. Temperatures as high as one million degrees may be obtained this way, but although this effect may be used to contain the plasma as well as to heat it, it is not too stable and allows the hot plasma to hit the walls of the tube and evaporate them. Neutron emission can be used as an indication of the temperature since as the temperature rises, the number of fusions increases and consequently the number of neutrons given off as fusion products increases. However, the instability of the "simple pinch" allows runaway particles to knock neutrons out of the walls of the tube, thus upsetting the neutron count with false readings.

The pinch effect has several characteristic unstable forms, one is the sausage effect and the other is the kink effect. By producing a longitudinal magnetic field inside the pinched column of plasma, the sausage effect can be eliminated. The kink effect is alleviated by using a return conductor to neutralize inequalities in the field. In some experiments done by Colgate and Furth as described in *Science*, it was found that the simple pinch increased in stability as it grew longer and that the stability is also dependent upon the resistance of the plasma, a result which agrees with work done by Lyman Spitzer at the Project Matterhorn laboratories at Princeton. It is found that if the current in the plasma surpasses a certain value, a hydro-magnetic kink instability develops.

The use of magnetic fields to heat the plasma is being used at present at Princeton University's James Forrestal Research Center. The Stellarator devices which are being used at Princeton employ a method called magnetic pumping to heat the gas after ohmic heating loses its value at about one million degrees. The pumping system alternately expands and contracts the lines of force in the tube, heating the plasma on contraction and cooling it on expansion. The net effect, however, is heating. This is because of a resonance effect created when the frequency of the pump is attuned to one of the periods of the Stellarator, i.e., the time between collisions of the particles, the time to pass through the region of pumping or the time taken to gyrate around the magnetic lines in one cycle. Resonating the pumping frequency to one of these periods causes the intake of energy to exceed the output of energy in a



Ted Loane

Cross-section of the divertor mechanism. The thin lines are the plasma particles. The dark sections are the magnetic coils which skim off the outermost layer of particles, thus decreasing the amount of impurities in the tube.

heating-cooling cycle. Instability problems arise in the case of magnetic pumping also. In the machine at Princeton, the actual device used is in the shape of a torus instead of a linear tube. This is because the heat generated in the fusion reaction is so great that if the plasma were allowed to touch the electrodes (as it would have to in the case of a linear tube) it would vaporize them, destroying the electrodes and cooling the gas down with impurities. The use of a racetrack or figure eight shaped tube eliminates the possibility of vaporizing the electrodes since none are needed—the plasma forms a closed circuit upon itself. This change in shape from the ideal tube introduces new difficulties. In the case of a straight tube, the pinched or constricted plasma will tend to stay in the center of the tube because the magnetic field is strongest there. But when the field is made to "turn corners" as it were, the magnetic field becomes non-uniform, concentrating around the inside of the curved surface. This causes the positively and negatively charged ions to separate, positive charges going to one side of the tube and electrons moving to the other side. This separation of charges causes an electrical field to be set up which disrupts the field completely, the reason being that the charges have no way of leaking back across the magnetic field to neutralize each other again. Since electric charges can only leak along the lines of flux, and the magnetic field is parallel to the axis of the tube—not at the top one minute and at the bottom the next, the charges are forced to remain separate.

Twisted Magnetic Field

It was found after experimentation, that the separation of charges could be compensated for and eliminated at the same time. If the magnetic field could be given a "twist" so that the lines of force traced out a helical path around the axis of the tube, they would trace out a "magnetic surface," which would have the property of being at all points in the tube within a certain time. This is actually done in two ways; an external magnetic field is applied longitudinally along the bottle which twists the field, or the torus itself is twisted into a figure eight causing the magnetic field to go through a rotational transform angle around the tube. This angle increases as the distance from the axis of the tube increases. The separation of the charges was eliminated because they are constantly pulled in one direction. If the ions move too far above the axis, the lines of force will pull them back. If they go too far below the axis, the unequal magnetic field will cause them to rise. In addition, because the lines of force trace out a magnetic surface, they are alternately at the top of the tube at one moment and at the bottom at the next. This effectively allows the charges to flow along the lines and neutralize themselves without disrupting the magnetic field.

Further problems in heating the plasma arise from "runaway electrons." As the particles move faster and faster, due to heating to the enormous temperatures referred to above, they tend to participate in fewer and fewer collisions, thus, they speed up until they escape the magnetic field entirely, crashing into the walls of the bottle and dislodging heavy atoms and particles which contaminate the gas and cause it to cool due to the greater heat radiating capabilities of the heavier particles. The most serious effect, however, is a thing called "pumpout." Particles seem to vanish, perhaps hitting the walls of the tube and embedding themselves there or knocking off heavier atoms from the walls. In any case, the effect is not desirable.

Reduction of impurities from any sources can be effected by the use of a divertor which does exactly what the name implies. By the use of a magnetic field, particles which travel around the very edge of the field are skimmed off and eliminated by the use of vacuum pumps. Further reduction is possible by baking the tube for a number of hours with the vacuum pumps on or by a newly discovered technique of rapid pulsing at low confining fields. These methods bring the amount of impurities down to a negligible value.

Briefly, the fusion reaction must be confined for a certain period of time before it can be left to run alone. Different approximations seem to give a value of about one second to start and continue the reactions. Power from these reactions can be obtained in the standard way—the heat exchanger method could be used to drive turbines with steam generated from the heat.

The newest effort at Princeton is the model C Stellarator which uses the best parts of previous Stellarators in its design. It is now being built, with a 1961 completion date in mind. It will involve heating by resistance methods, then by ion-cyclotron resonance heating. The power circuits will involve large d-c generators and vacuum tubes. De-ionized water will be used to cool the magnetic coils and two separate radio frequency supplies will be used to provide additional heating.

Other Research

Just recently, the Naval Research Laboratory has announced that it has "apparently" achieved a small fusion reaction using a short linear tube to contain deuterium plasma (similar to hydrogen, but with two neutrons in the nucleus). The magnetic mirror effect is used to confine the plasma and the gas is heated and confined in a process taking about ten microseconds. Within one microsecond, a temperature of three million degrees was reported. The interesting feature of this attempt is that after a preliminary oscillation, the plasma seems to settle down in the center of the tube, exhibiting none of the usual hydromagnetic instabilities characteristic of other methods. At about seven microseconds, the neutron emission hits a peak of about one hundred million. Another recent development at the Los Alamos Labs is the result of creating a magnetic field in the shape of four cusps curving inward. It is based on the theory of entropy trapping which implies that if the particles in the plasma are kept in the field while they are being heated, they will randomize so that they will tend to *stay* in the field.

As we obtain more facts and continue to experiment, a time will probably come when man will be able to forget his worries about running out of fuel, and will be able to build his future around power from fusion.

ABOUT CIVIL ENGINEERING

by M. D. Morris, C.E. '44

The classic image of the surveyor in lion-tamer pants and a campaign hat has not been the true picture of the civil engineer for several decades. Now neither the man nor the field is static, and his sphere of influence is as limitless as outer space. Some of the things civil engineers are working at these days range from space survival, superhighways and radio telescopes to art museums, aerial photographs and reactor plants.

In the old days all engineering was for the military. Ever since Marcus Apius used his ingenuity to build the military roads that led from Rome, engineers have constructed "impregnable fortifications"—and means for their ultimate destruction. About the time of the American Revolution, one British engineer felt that some thought should be given to civic development, and so in London in 1777, the first shingle appeared reading, "John Smeaton, Civil Engineer." Since then buildings, roads, water supply, sanitary facilities, traffic patterns, tunnels, management, and other public works have become an honored preoccupation.

Seventy-five years later, the American Society of Civil Engineers was founded here, and since 1852 Mechanical, Mining and Metallurgical, Electrical, Chemical, Aeronautical, Nuclear, etc., engineering have branched off as separate fields from the parent society. But the direct work for the public good remained with the "civils."

Satisfaction in this field comes from tangible results and their usefulness, from such civil engineering accomplishments as a pipeline delivering natural gas from Oklahoma direct to Boston; a tower standing dry and fixed thirty miles out at sea pumping oil from far below the stormy ocean's bottom; and the San Francisco-Oakland Bay Bridge. In 1942 a young man in charge of his first survey crew laying out the boundary fence of the Rome, New York, Army Air Force Base paused on a tall hilltop to look back and admire his straight line of stakes. They led in perfect alignment from his instrument back down the hill, across a broad swamp, and up over another hill. This he thought, was something of man's conquest of nature. Last year, when other work brought him back to Rome he found part of his fence gone, along with the two hills. They had been leveled off and used to fill the mile or so of swamp that was dredged away, and a large airstrip ran over the whole area. In this quest for satisfaction, progress beyond earlier expectations becomes the by-product.

M. D. Morris

Civil engineers remove slum areas and replace them with modern useful structures with a minimum of interruption to daily life.

Relation with Other Fields

The civil engineer has become the skeleton analyst to the other engineering professions because he knows the nature of the materials of engineering (soil, steel, aluminum, wood, concrete, glass, etc.), and studies the behavior of these materials in various structural shapes. For example, the latest way of learning about the number of stars, their composition, and their direction of motion in, say, the great spiral nebula in Andromeda (nearly a million light years away) is by radio telescope. This large gossamer steel web catches spatial radio waves in its bowl-like shape. Civil engineers design these to insure greatest strength with a minimum of extra "non-working" parts. The basic structural skeleton of the huge Boeing 707 jet air transport that flies from Los Angeles to New York in 4¾ hours was designed by a C.E., just as were the airfields it uses for landings and takeoffs. As aircraft became bigger and heavier they require stronger and thicker pavements to support their weight and impact on landing. Just any kind of pavement won't do either, it must be such that it will not deteriorate from kerosene or more exotic liquid fuels.

Everything built by man (airports, roads, buildings, dams, tunnels), depends upon the soil for its foundation. The soil must be able to support structures without settling, or displacing other soil elsewhere. It must hold water if it is an earthfill dam or transmit water if it is a sand drain.

Because soil is not constant like steel or concrete, it requires an entire school of study for itself called Soil Mechanics. "Dirt-men" today are adding chemicals to the earth-in-place and coming up with stabilized, hard surface roadways. They inject chemicals into the ground to form firm foundations for buildings where unstable conditions existed. It was that way under the mammoth Chase Manhattan Bank Building in downtown New York.

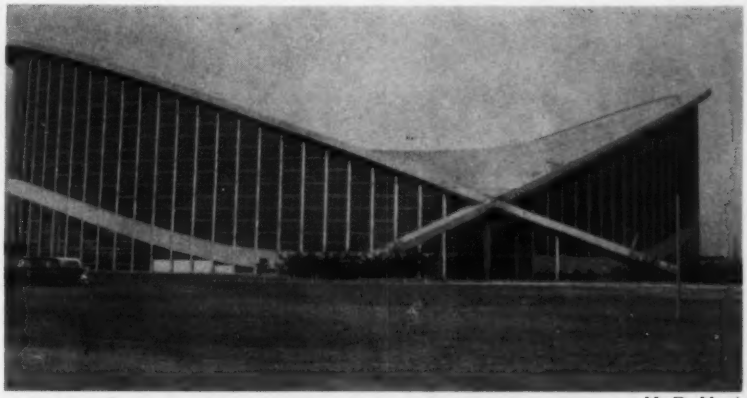
Superhighways have become so much a part of our daily lives that a confused person is no longer "at the crossroads"—he's at a cloverleaf. One can now drive across several states on thruways, parkways, turnpikes, and freeways. As soon as the linkage is completed, he will be able to drive the Interstate System from New York to San Francisco without stopping for a traffic light. There will be toll gates aplenty though, for a long time to come.

Population studies of trends leading to special planning for mass-transportation is also C.E. work. This includes determination of traffic patterns, routes, and even of location of new roads. There *is* a definite reason for that new one-way avenue in town!

New Techniques Ease Work

All things that once required years of exploration on foot are now accomplished rapidly and expertly in days by specialists in air photo interpretation, the newest of the civil engineering techniques. This applies to dam location, drainage patterns, highway routes, large area land use studies, geological structures, and terrain analyses.

Cero Bolivar, U.S. Steel's magnificent mountain of iron in Venezuela, was discovered by noticing in an air photo a type of mountain laurel that grows only in soils containing iron salts. "C.B." now produces more than ten million tons of first grade ore per year. At the mine there is a complete and self-contained city including power, water supply, sewerage, etc. A highway and a railroad run from the mine to the Orinoco River junction 60 miles away where another city, a port, was built complete and self-contained. There, the ore is taken from the railroad cars, processed, and loaded onto ocean-going steamers. These will go nearly one hundred miles down the newly dredged riverbed before starting the voyage across the Caribbean and the Atlantic to United States refineries. Civil engineers planned and built that whole operation with the aid of the other engineering professions.



M. D. Morris

Roof hung by cables from prestressed concrete arches gives the State Fair Arena in Raleigh, N.C., complete interior visibility that is column free.

The buildings for highly specialized atomic plants, reactors, "hot goods" storage, and disposal of radioactive waste have also been designed for nuclear physicists and other scientists by C.E.'s. The massive concrete housing for a reactor is a new study unto itself, as are the block launching pads for the Jupiters, Thors, Atlases, and Vanguards, with their superstructures for count down.

Electronics men and mathematicians have produced a new tool to change the work sphere of the civil engineer. By making use of both digital and analogue computing machines he can figure highway cuts and fills, traffic studies, population futures and complex problems in statically indeterminate structures, in a fraction of the time formerly needed.

Survival in Space

Survival in a capsule hurtling through space at terrifying speeds is also a civil engineering concern. A government grant is supporting research by sanitary (civil) engineers at New York University to find the best way to store supplies of oxygen, palatable food, water for drinking, cleaning, and cooking. These men seek ways to maintain the oxygen-carbon dioxide balance to sustain life; ways to control any toxic substances in the capsule's limited air supply; ways to store and reconstitute body wastes and maintain comfortable temperatures and humidity on long, long trips.

But down here on earth architects are designing buildings in accordance with their wildest dreams. Thanks to new civil engineering concepts in concrete, steel, aluminum and wire uses, these dreams suddenly become real buildings. Thin shell shapes hang from their self-supporting selves by cables. Concrete walls are pre-cast in molds at work-yards, and prestressed by pulling imbedded wires tight while the mix is still plastic. After being dried and cured they are tilted up into place by huge portable cranes.

As for the future in engineering for the public good, it is hard to guess because all things in these dynamic days move so rapidly. It has not been quite 200 years since John Smeaton's monumental "little revolution."

About the Author

Mr. M. D. Morris, C.E. '44, has worked on engineering projects in all parts of the world since his graduation. The last ten years he has spent as a consultant in materials testing methods and equipment in Europe, Greenland, Latin America, and the United States.

Author of over 100 published works, Mr. Morris is a contributor to two McGraw-Hill publications, Chairman of the Division Publications Committee of ASCE, and holds membership in several professional societies.

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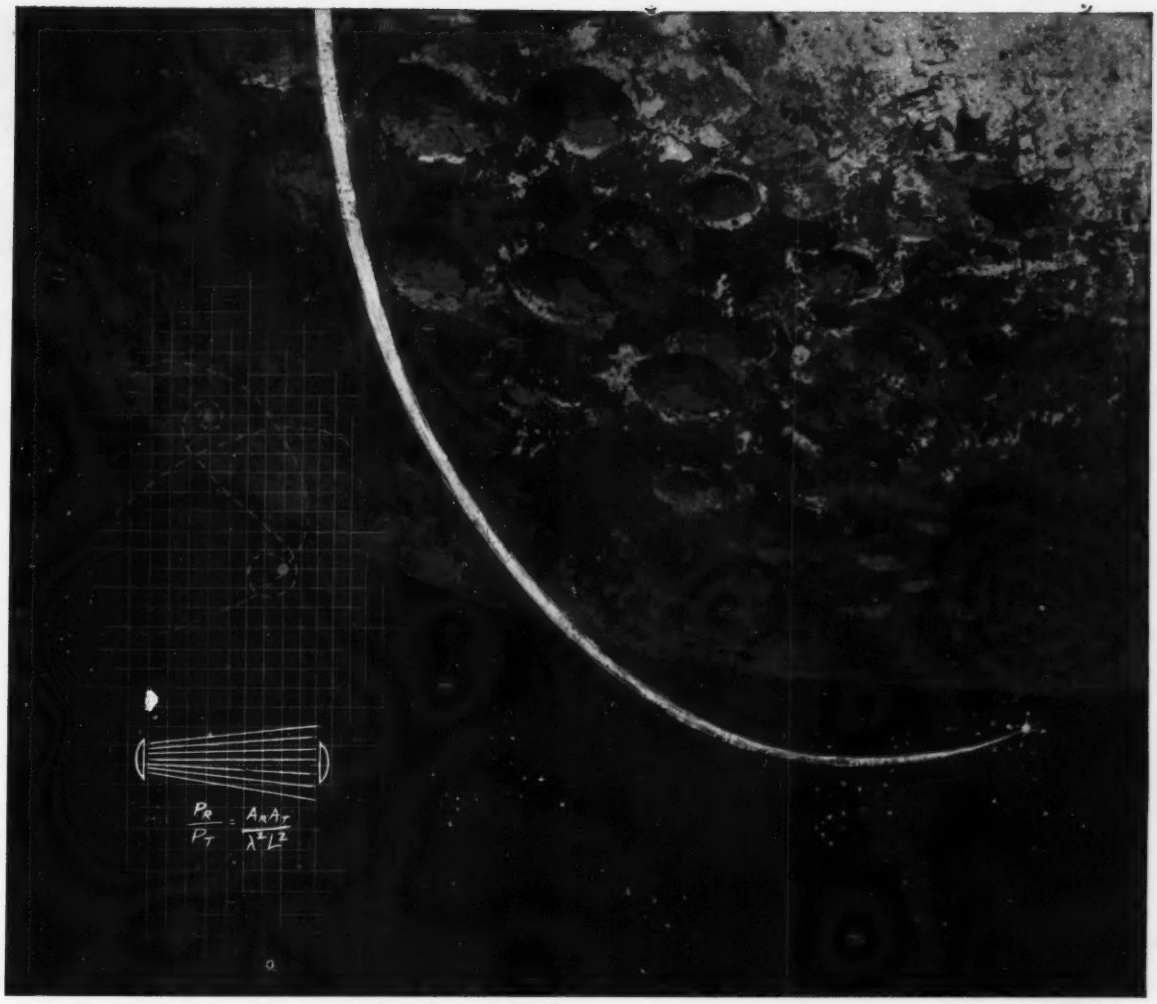

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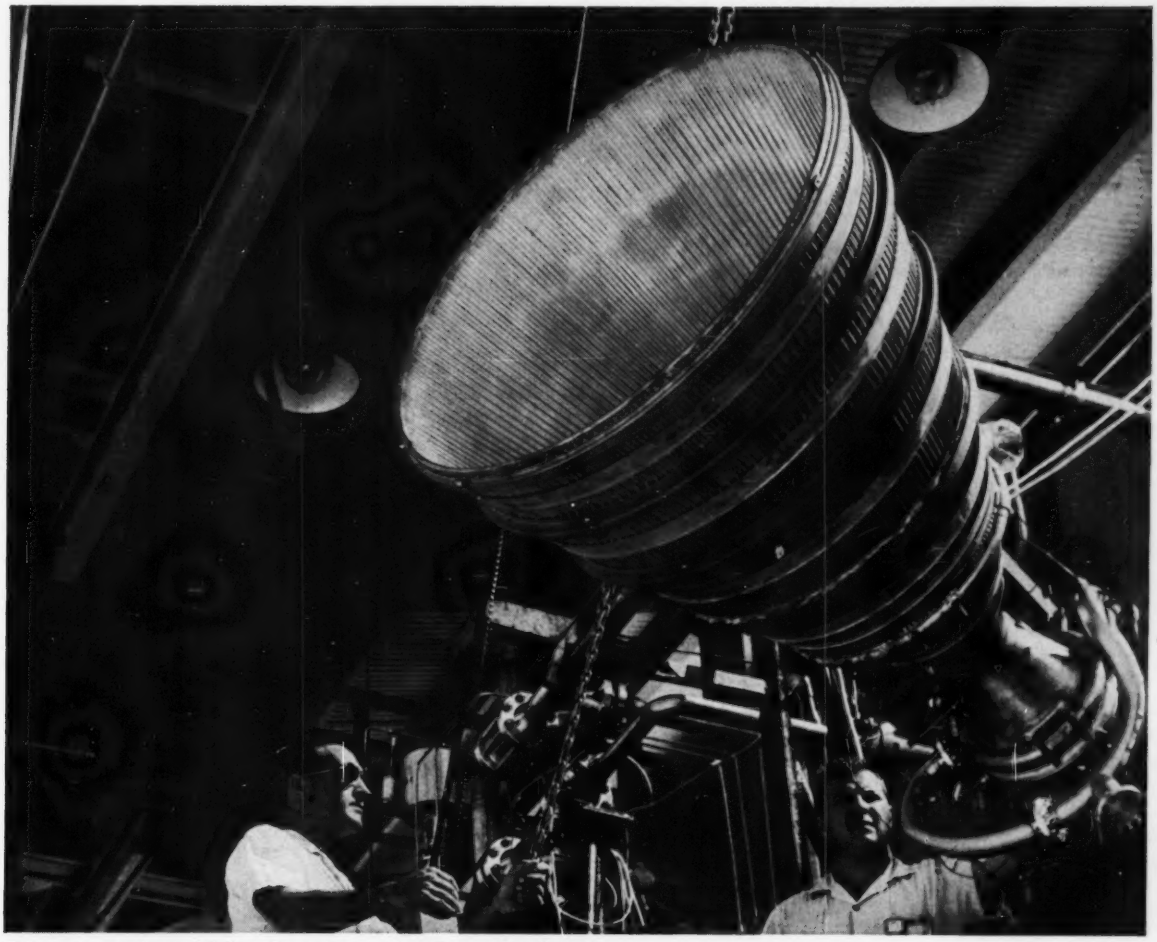

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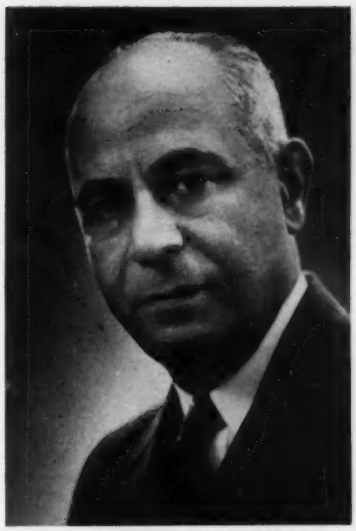
Faculty Profile . . .

PROFESSOR MICHEL G. MALTI

by Richard A. Wolff, EP '62



Buzzell Photography
Professor M. G. Malti

Professor M. G. Malti of the School of Electrical Engineering has distinguished himself both by his work as an educator and by his contributions to electrical theory and applied mathematics. Anyone who has taken a course under him will agree that his teaching methods are unconventional and yet effective. He has written a number of significant books and articles dealing with the applications of physics and mathematics to electrical theory. As an engineer, he has done considerable work on dielectrics, circuit analysis, and the analysis of rotating machines.

The story of Professor Malti's rise to his present eminent position in electrical engineering is a very unusual one. He was born at Deir-ul-Kamar, Lebanon, the son of a pharmacist. Although his father wanted him to study medicine, he decided to take up engineering. He attended the American University of Beirut and received the A.B. degree in 1915. His next goal was to earn enough money to finance his trip to America, where he was to begin his study of engineering. He spent one year teaching in the preparatory department of the American University of Beirut. The school, Professor Malti says, was similar to many American schools in that discipline rather than study was emphasized. Commenting on this experience, Professor Malti stated, "After one year of this, I swore I would never teach."

He also found that teaching school was not helping him save money toward his trip to America. Professor Malti relates that his next job was that of secretary of a turf club organized by the occupying forces in Lebanon after World War I. Under the previous secretary, the parimutuel of the club had consistently accomplished the mathematical impossibility of losing money. Having gained a reputation for honesty, Malti was selected as the new secretary.

He soon earned enough at the turf club to finance his trip to America. He joined the cooperative program at Georgia Institute of Technology. Professor Malti emphasizes that his experience in the cooperative program was invaluable. He had come from an unmechanized country and the program offered him his first contact with industrial machinery.

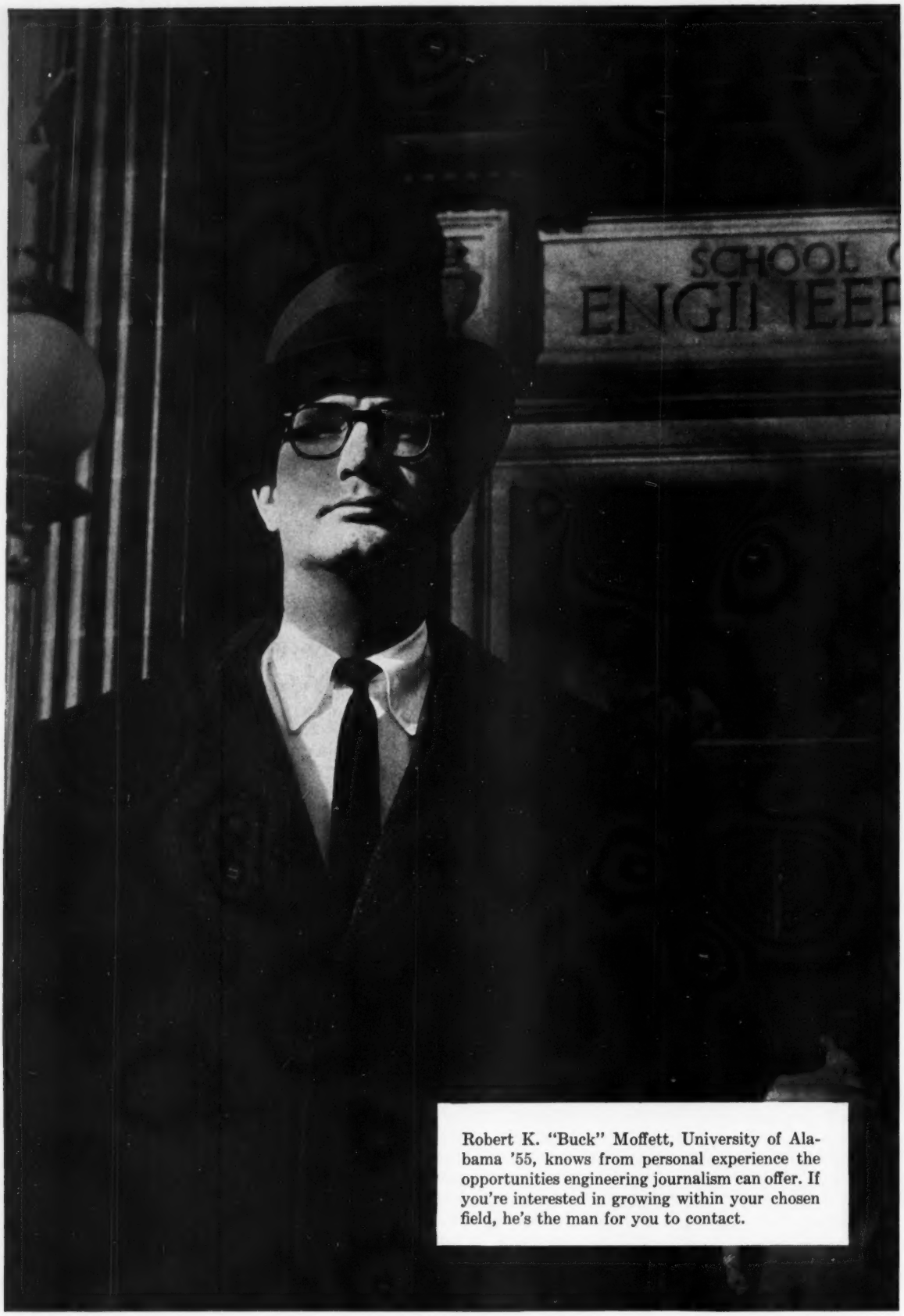
By the time he had received his B.S. in E.E. degree from Georgia Tech, the money he had saved in Lebanon had run out. Seeking work in the Atlanta area, he was referred to a local architect who was in charge of surveying a tract of land. Professor Malti relates that although he didn't know it at the time, the land was owned by the Ku Klux Klan and was to be subdivided into building lots and sold to Klan members. Despite the fact that foreigners were not officially in the good graces of the Klan, Malti remained on the project all summer. Impressed by the young engineer's diligent work, the architect in charge of the project offered to go into partnership with him. But, still wanting to continue his study of engineering, Malti refused the offer.

Having saved $350 from his summer's work, he wrote to the graduate school at Cornell. His letter was referred to Rev. John D. Fetter of Cornell United Religious Work, who advised him to stay in Georgia until he had saved at least $1000 for a year's study at Cornell. Less than a week later, Malti walked into Rev. Fetter's office. Admiring his courage, the clergyman helped him to get work which allowed him to support himself for a year. The next year he became an instructor and was thus afforded a steady income.

He received his M.E.E. degree from Cornell in 1925 and his Ph.D. in 1927. Since that time, he has written texts on electrical circuit analysis and Heaviside operational analysis as well as some thirty papers representing his research in various fields of electrical engineering. Professor Malti was recently elected a fellow of the American Institute of Electrical Engineers ". . . for contributions to electrical engineering education through his teaching and publications."

Although Professor Malti is associated with the College of Engineering, he takes the liberal arts point of view toward education. The ideal university, he believes, is one in which all students are required to take courses designed to develop their thinking. According to Professor Malti, the well-educated man is the one who has a well-disciplined mind. Such a person, he feels, could educate himself in any field, following the curriculum set for that field.

Professor Malti stresses that, in his courses, he tries to teach disciplines rather than subjects. He is not interested in teaching the facts involved, but only the methods of thought used. He emphasizes the importance of accuracy in all engineering computations. Through his lectures and problem sets, he also attempts to destroy the young engineer's fear of long equations.



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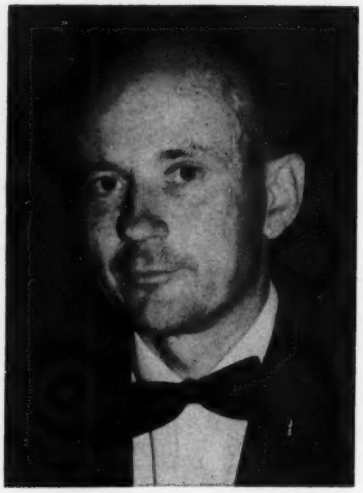

S. D. Teetor

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students, and to establish closer relationship between the College and its alumni."

THE PRESIDENT'S LETTER—

ETHICS

Many words have been both spoken and written on a given subject, but judging by the progress, to date, it would appear that a few more would be appropriate. The portion of the ethical question that I will discuss is the one which pertains to competitive bidding for Engineering services. Possibly, being in the Consulting Engineering branch of the profession myself, I have had the benefit of observing, first-hand, the pros and cons of the so-called "commercial" approach vs. the "professional" approach in the selection of Engineering Firms to carry out projects by different clients.

Many industrial firms and Government groups, when under the control of financiers or others that have not had any real experience in Engineering projects, think that they can easily save their company, or agency, money by obtaining three or more prices on Architectural or Engineering design fees per project. What they fail to realize is that up to a reasonable limit, the more time and effort that a professional man spends on a project, the lower the total project will ultimately be. Having had the opportunity of studying the plans prepared by other Engineering firms which had obtained their contracts on a price basis, and, in other, even more unfortunate, cases of having studied the construction after it may have failed, it becomes more obvious to me that for every dollar saved, $1.00 to $1,000 extra may ultimately be required. In many cases purchasing agents for many corporations are far more interested in showing their superiors that they have followed out the prescribed regulations for competitive pricing than they are in what the ultimate project cost will be. We can also find Engineers (working for corporations) who are hard-put to sell the head of their division on the fact that Engineering for certain projects may cost, in terms of percent of construction costs, five times that of a previous project of a different nature. It is up to all Engineers to help progressively educate the appropriate people so that ultimately all people in sensitive positions will eventually understand the fallacy of saving $1.00 today and spending $10.00 extra tomorrow. Unfortunately, from the appearance of progress to date, the education will be a long period.

STEPHEN D. TEETOR '43
President

ALUMNI ENGINEERS

William J. Zabel, C.E. '14, retired in October after forty-five years with the New York State Department of Public Works. His job included the operation and maintenance of the Rochester area's 80 miles of canals and flood control. The District Engineer described him as "one of the outstanding men in canal work in New York State." He added that Mr. Zabel's knowledge of the canal system "is phenomenal."

Gordon B. Lankton, B.M.E. '53, has recently joined the Stanley Chemical Co., East Berlin, Connecticut, as sales and technical engineer. Mr. Lankton is in charge of the sales, engineering, and production of the precision plastic injection molding business of the company. Previously he was a plastics technologist with E. I. du Pont de Nemours. Mr. Lankton did his service as a first lieutenant with U.S. Army Ordnance in Germany, where he attended Goethe University in Frankfort. He has also done graduate work at the University of Delaware.

John O. Brown, E.E. '45, has been appointed manager of the new Birmingham, Alabama, district office of the I-T-E Circuit Breaker Company. In his new capacity, Mr. Brown will handle sales of the Company's electrical products in Alabama and northwestern Florida.

John O. Brown

Before assuming the I-T-E post, Mr. Brown spent seven years as a field application engineer with Joseph W. Eshelman & Company in Birmingham. He attended both Princeton University and Cornell, receiving the B.E.E. from Cornell in 1945. He served in the United States Navy during World War II. Mr. Brown is a member of the Association of Iron and Steel Engineers.

John L. Patterson, Chem. E. '36, is now assistant manager of film manufacturing for the Eastman Kodak Company. Mr. Patterson joined the Company at its chemical plant at the Kodak Park Works in Rochester in 1936. In 1943, he moved to Oak Ridge, Tenn., where he became superintendent of the Chemical Division of Clinton Engineer Works, which is an affiliate of Kodak's Tennessee Eastman Division. After returning to Rochester in 1947, Mr. Patterson was appointed assistant superintendent of the Chemical Manufacturing Division. He was transferred to the same position in the Photochemical Division in 1954 and has been serving as assistant manager of film manufacturing since 1955.

Alumni News

John L. Patterson

Harold C. Yost, B.M.E. '45 and M.M.E. '49, has been appointed as director of reliability for the Milwaukee operations of the AC Spark Plug Division of General Motors. Mr. Yost comes to this new position after working with the Thor missile and with Ramo-Wooldridge Corporation of Los Angeles.

Alumni News

Harold C. Yost

Colonel Carroll K. Moffat, C.E. '27, of the United States Army recently ended his military career after thirty years of service. Upon his retirement he was awarded the Legion of Merit medal for his outstanding services in the varied positions in which he has served. The award was presented by Brigadier General Robert C. Tripp, commanding officer of the Army's Transportation Terminal Command.

Colonel Moffatt received his commission in the Army Reserve from the University Reserve Officers Training Corps and entered active duty in 1940. During World War II, he established the first Army posts in New Guinea. After the war he served as chief of the Economic Defense Division with the Seventh Army in Europe. Returning to the United States, he took over command of the Bay Area Transportation Terminal Center, which operated all Army ports in California. At his retirement, the colonel was deputy commander of the Army Transportation Terminal Command, Pacific, with headquar-

ters at Fort Mason, California. He had held the post since 1950.

William E. Blewett, Jr., M.E. '18, President of the Newport News Shipbuilding and Dry Dock Company, was recently honored by his firm for forty years of continuous service. He began his employment in August, 1919, in the engine-drawing room. He served as assistant to the president from 1930 to 1936, as production manager from 1936 to 1947, and as executive vice president from 1947 until January, 1954, when he was elected president of the Company.

Captain B. Otto Roessler, C.E. '31, of the United States Navy has been transferred from Pensacola, Florida to Great Lakes, Illinois, where he is deputy district public works officer and deputy officer in charge of construction for the Ninth Naval District.

Robert F. Boehm, M.E. '51, has been appointed staff engineer at the Owego, N.Y. facility of IBM's Federal Systems Division. Having joined IBM in 1954, Mr. Boehm has done work in the areas of development, physical research, systems research, patent engineering, and systems analysis.

Alumni News
Robert F. Boehm

Richard E. Coykendall, M.E. '51, was a co-author of two papers presented at national conferences. "Jet Transport Problems during Takeoff and Landing" was the title of one of his papers, which was presented at the Society of Automotive Engineers national aeronautical meeting in New York. The other paper, "Runway Lengths for Jet Transports," was presented at the second jet-age airport conference of the American Society of Civil Engineers held in Houston. Mr. Coykendall is an aeronautical engineer with United Air Lines in San Francisco.

Edward W. Carson, C.E. '33, was recently promoted to manager of Philadelphia Electric Company's Service Operations Department. He joined the Company in 1935 as a cadet engineer and worked his way up to become general superintendent of the Appliance Service Division, and, most recently, assistant manager of the Service Operations Department.

D. R. Pulver, Chem.E. '51, has been appointed technical superintendent of the Belle, West Virginia plant of the Diamond Alkali Company. After joining the Company in 1952, he was assigned to the technical staff of the Company's division in Cleveland, Ohio.

Correction: December, 1959; Alumni Engineers. John C. Gibb, M.E. '24, works for the Socony Mobil Oil Company, Inc.

To students who want to be SUCCESSFUL highway engineers

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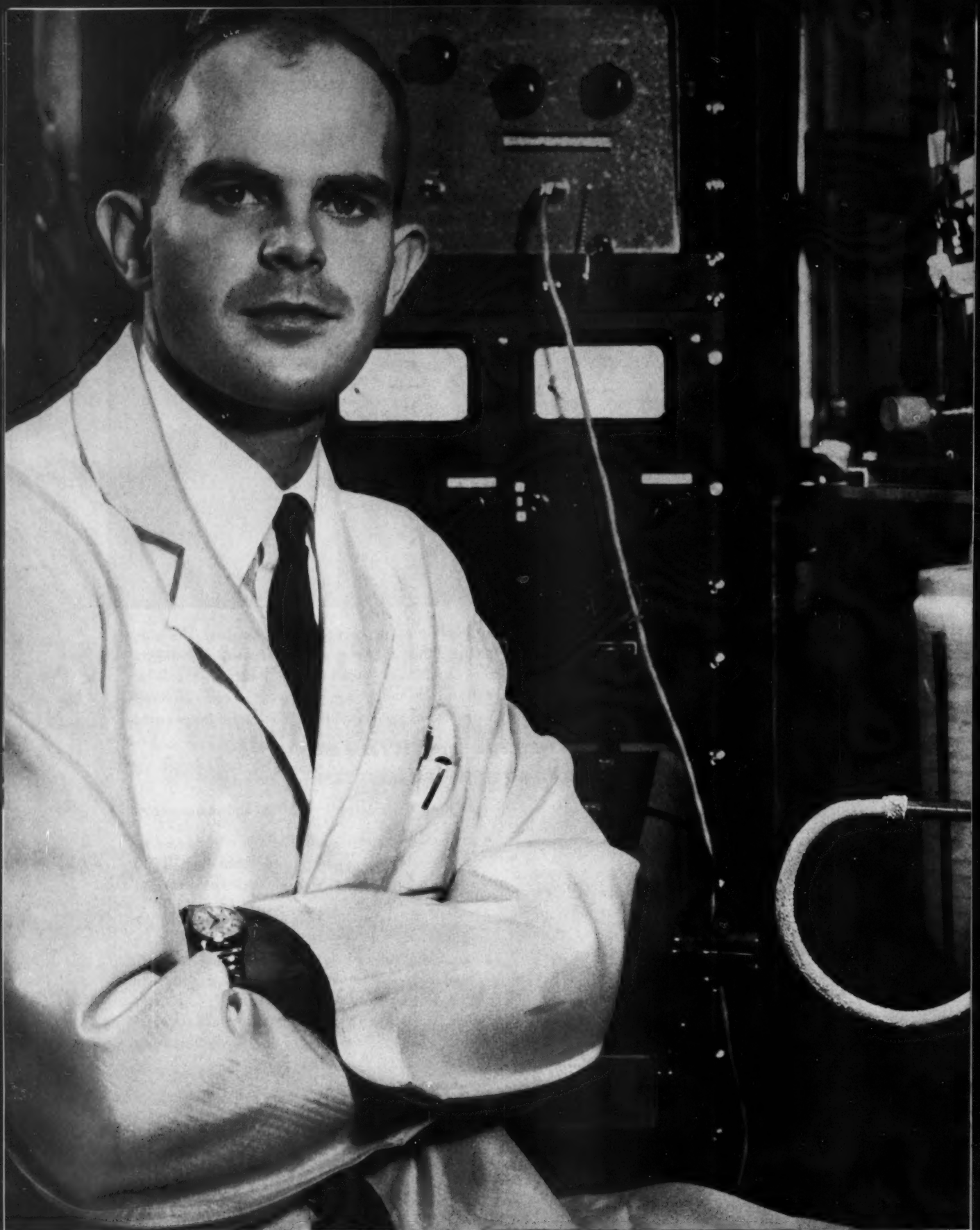

D. J. Dumin (E.E. '57) earned his degree at Johns Hopkins. An Associate Engineer at IBM, he is doing original work in the design and testing of thin film circuits. Two of his ideas in this field have been filed upon for patents.

HE'S WORKING TO GIVE OLD METALS A NEW FUTURE

The metals now being utilized in thin film development have been known and used for centuries. But dormant within these metals has been their quality of superconductivity at extremely low temperatures. Only when researchers were able, with great ingenuity, to create certain relations between metals and changes in their basic structures, could these superconducting qualities be utilized. But much remains to be done at this moment, especially in the application of thin metallic films to practical working devices.

Development Engineers at IBM are at work daily on the problem. They envision the replacement of today's electronic logic elements with modules of amazing responsiveness, durability, and simplicity. The extremely small size of these modules and their low power requirements will be important factors in shaping the electronic systems of the future.

Closely allied on this work are engineers of practically every specialty. Only by bringing the talents and abilities of people of many fields to bear on the unique problems of thin film development, will progress be consistent with objectives. Engineers at IBM expect to obtain these objectives, and once they are obtained, to set new ones.

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COLLEGE NEWS

Edited by R. A. Stern, EE '63

E.E. SCHOOL INTRODUCES MATH PROGRAM FOR SELECTED STUDENTS

The electrical engineering faculty has recently passed a resolution which will allow selected students to take a special program in mathematics while completing the normally required subjects in the curriculum. The new program will give the engineer a sounder basis in math, which is always desirable if not possible in the years in school.

Engineers who, in their third term, have cumulative averages higher than 80 may elect the special program. It consists basically of the math 612–616 series and other small additions to the basic program. For the students electing the course, the math series is added and machine design 3341, fluid mechanics 2331, and E.E. 4114 are omitted. This results in a gain of five non-elective hours which may be taken from the free or technical elective category.

In the special program, the total credit hours in physical chemistry and engineering materials remain the same as in the regular curriculum, but the division is different. The omission of fluid mechanics is to be partially made up by arranging the schedule of the fourth term so that students in the special program take the course in dynamics 1152 which is taught to engineering physics students. This version of 1152 includes four weeks of work in fluid mechanics to make up for the elimination of the 2331 course. In addition, engineers in this program may elect to take mechanics of continua, 8131, in the tenth term which also includes work in fluid mechanics. Course 8131 requires math 616 as a prerequisite.

In particular, the basic course will be changed as follows: thermodynamics 3630, which is normally given in the fourth term, will be given in the fifth term in the special program; physical chemistry 401 will be given as physical chemistry 402 in the fourth term along with math 612. Materials 1241 will be deleted and materials 1201 will be given instead in the seventh term. Three non-technical elective hours will be removed from the fifth term and added to the last two terms to allow for math 613.

The Faculty Committee assumes that those who elect the new program expect to complete it. However, in the event that the student is forced to drop out of the program for any reason, he will have no difficulty in fitting into the regular program again. Those subjects which have been deleted up to the date of dropout will be made up of free hours in later terms. Students who have "invented" an advanced program for themselves before the introduction of the new program will be able to enter it officially at the level of their achievement.

TAU BETA PI HONORARY HOLDS FALL ELECTIONS

Tau Beta Pi, the engineering honorary society, recently elected new members to its ranks. The honorary's purpose is to recognize leaders in scholarship, industry, and education.

Those elected from the Class of 1960 were F. W. Ballou, L. M. Holmes, A. R. Newhouse, C. W. Stewart, all EE's; J. A. Braff, R. C. Metzger, R. W. Robinson, all ME's; M. C. Deibert, C. R. Fox, N. T. Joyner, all ChemE's; R. A. Handelsman, R.G. Seybold, EP's; and M. Lehman and A. Mauri, architects.

Honor students elected from the Class of 1961 were P.J. Mode, Jr., ME; and R. S. Queener, CE.

An initiation was held in December in Phillips Hall, after which there was a banquet. Dr. T. P. Wright, vice president for research, was the guest speaker.

ELECTRICAL ENGINEERING HONORARY HOLDS ELECTIONS

Eta Kappa Nu, the electrical engineering honorary, held its elections recently. Active in both the town of Ithaca as well as in the University, the members are conducting a course evaluation program in the EE school, have sponsored a lecture series in science and math for Ithaca High, and are also in charge of many student-directed activities in the EE school. New members elected were F. W. Ballou, P. B. Bowman, G. A. Chayt, E. B. McCrohan, and T. H. Roelofs, all of the Class of 1960 and D. A. Berkley, J. B. Frazer, D. Sargent, and W. M. Wichman, all of the Class of 1961.

N.Y. ACADEMY OF SCIENCES ELECTS JOHNSON FELLOW

John R. Johnson, Todd professor of chemistry, has been elected a fellow in the New York Academy of Sciences. Election to fellowship in the Academy is conferred upon a limited number of members who, in the estimation of the Scientific Council, have done outstanding work toward the advancement of science.

Professor Johnson is a leading expert in organic chemistry. He has done work with organo-boron compounds, ketene and furan derivatives, and the structure of the antibiotic, gliotoxin. His most recent work has been in the field of biosynthesis of natural rubber. He is the author of numerous articles and co-author of a monograph, "The Chemistry of Penicillin," a report on all the research done in this field during the war.

Professor Johnson graduated from the University of Illinois and received the M.S. and Ph.D. degrees there. He taught there for three years before coming to Cornell in 1927 as an assistant professor. He was promoted to professor in 1930 and was named Todd professor in 1952. He is a member of the National Academy of Sciences.

DONALD H. MOYER STRESSES QUALITY IN ENGINEERING

According to Donald H. Moyer, director of the Office of Student Personnel, College of Engineering, an engineering degree is no longer a passport for college graduates to executive-sized jobs and salaries.

Director Moyer said, "An engineering degree per se is no longer an open sesame to a good job." He said that at one time the intense competition for engineering graduates which developed caused

many companies to train liberal arts graduates to fill jobs previously held by engineers. Many companies hired technicians to fill such positions. The demand for high quality engineers began in 1958, he pointed out, during the recession when work slow-downs and layoffs resulted in industry retaining only those of the highest calibre.

Director Moyer said he feels that the recent belt tightening by searching industries may result in an even more competitive atmosphere at Cornell. The companies are placing more and more emphasis on the quality of training, he said.

"Again this year, men in the top half of the class will have few if any placement problems," he predicted. "The below average student will get a job, but it may not be exactly the job he wants, or where he wants it, and to get it he may have to take the initiative and go beyond the confines of Cornell's Placement Office interviewing rooms."

An alternate outlook appears, however, when evaluating our present and future business trends. An accelerated economic expansion program could again shoot the demand for engineers skyhigh, he said, and if this country's business recovery is at all above average, the lucrative offerings to graduating engineers will once again occur.

In the meantime, an independently conducted survey shows that Cornell engineering graduates may have less to fear than their counterparts at other engineering colleges or universities. Results indicate that Cornell's five-year curriculum is paying dividends for graduate engineers in that starting salaries for Cornell-trained engineers more than offset the one-year headstart at working experience that graduates of other engineering schools get because of four-year courses.

University News

Professor J. R. Johnson, Todd professor of chemistry, was recently elected a fellow of the New York Academy of Sciences.

PARRATT RECEIVES GRANT FOR X-RAY SPECTROSCOPY

The Air Force and the National Science Foundation have granted a total of $224,600 for continuation of x-ray spectroscopy work being carried out under the supervision of Professor Lyman G. Parratt, recently appointed chairman of the physics department.

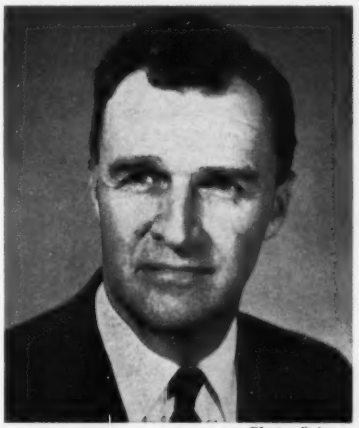
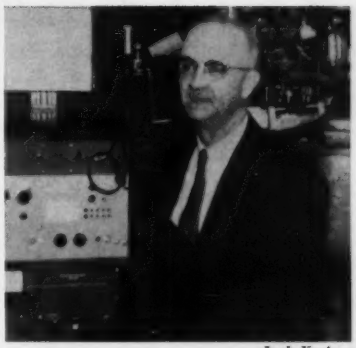


Photo Science

Donald H. Moyer, director of the Office of Student Personnel, has predicted that industry will become more selective in procuring engineering graduates.

Professor Parratt called the grant for "off-beat" basic research a gratifying step in the right direction. He pointed out that much of the technological progress made in recent years has been based on just this type of fundamental "off-beat" research. He cited photography, the telephone, radar, and the atomic bomb as typical of accomplishments that were preceded by basic research performed many years before the corresponding gadgetry was ever invented or put into production. He pointed out that when engineers are forced to develop technology in the absence of fundamental scientific knowledge, "the work proceeds slowly and is characterized by very costly mistakes."



Joel Kreiner

Professor L. G. Parratt, chairman of the physics department, has received a grant for the continuation of X-ray spectroscopy research.

Professor Parratt pointed out that although very few people except professional physicists have heard of X-ray spectroscopy, it is one of the research fields that made the Cornell University physics department world-famous decades ago.

The field is characterized as one in which there are no immediate or direct applications outside of basic science itself. Professor Parratt said that this feature of the work has its advantages as well as its disadvantages; X-ray spectroscopy attracts only intensely dedicated researchers who prefer to work in relative obscurity, he said. "But the importance of such work, both to basic science and to our technology in general is beyond doubt, as can be judged by the support represented by these two grants," Professor Parratt said.

Professor Parratt said that he and his colleagues are engaged in two general tasks. First, he said, his group is studying the inadequacies of the conventional X-ray energy level diagrams for gaseous liquid and solid materials, and that they are seeking a better type of understanding based on a so-called many-electron view of the dynamics of atomic behaviour. The second phase of his research concerns the physical and chemical structure of solid surfaces. The Cornell research group has developed a new method of study based on the reflection of X-rays from surfaces.

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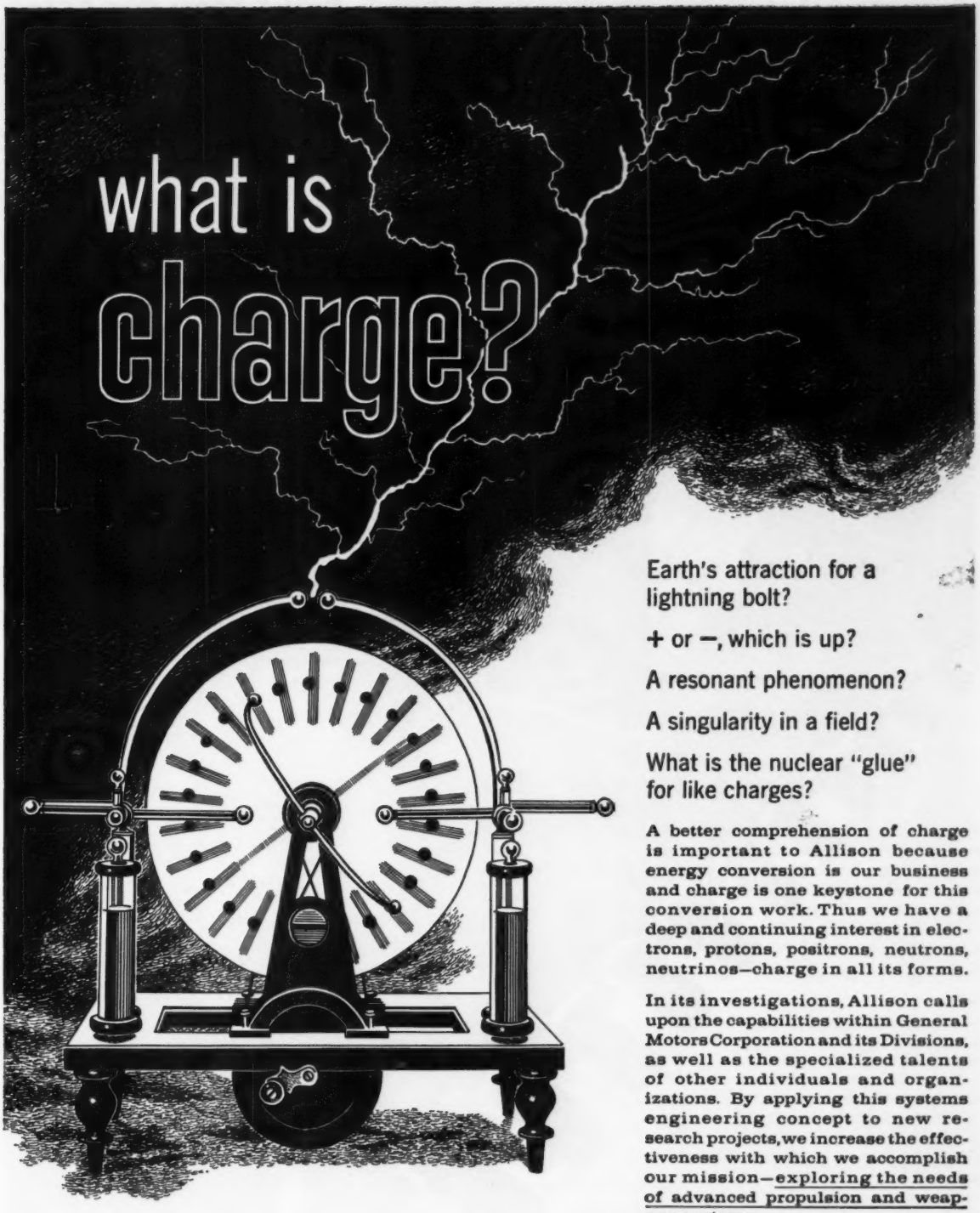
and the IRE, Mr. James Caroll of Westinghouse spoke on the scientific principles behind the thermoelectric effect and the use of thermocouples in refrigeration.

Briefly, the thermoelectric effect is evidenced when a voltage is generated due to a thermal gradient across two dissimilar conductors. While this effect was discovered during the 1800's, it did not come to any use until this century. Its most common application is in the form of a temperature indicator. However, because of the problems caused by heat and resistance losses and by inadequate materials, the thermoelectric effect has found few other uses.

It has recently been found that the process may be reversed to provide either heating or cooling upon the application of a polarized voltage. In order to produce a cooling effect, the materials involved at the joints must have low electrical resistance, high thermoelectric voltage, and low heat conductivity. A figure of merit based on these variables is used to rate materials. It was discovered that semiconductors are, on the average, better materials for thermocouples than most other metals like copper or steel. Also, if two different types of semiconductors are used (n- and p-types), the figure of merit is much higher than with similar-type semiconductors. The net cooling effect of n-p type of thermocouple is dependent on the thermoelectric effect, on i^2R losses, and on a thermal heat flow rate, as are all such units. The demonstration units clearly showed how the effects acted to produce heat and cold as well as some very compact refrigeration units which can be made small because the cooling units may be paralleled and used to aid each other. Mr. Caroll commented that the present lack of these products on the market is still due in part to materials shortages and competitive prices of electric or gas refrigerators. The demonstration units shown operated on direct current of from 20 to 80 amp and 2 to 4v. One of the more interesting demonstrations was a clock-radio controlled bottle warmer which first cools the formula, then heats it to temperature and rings an alarm when it is time to feed the baby.

what is charge?



Earth's attraction for a lightning bolt?

+ or −, which is up?

A resonant phenomenon?

A singularity in a field?

What is the nuclear "glue" for like charges?

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Millions of feet of tough, transparent polyethylene film are used each year to protect the freshness of perishable foods such as fruits and vegetables. Scores of other useful things are made from polyethylene . . . unbreakable kitchenware, alive with color . . . bottles that dispense a fine spray with a gentle squeeze . . . electrical insulation for your television antenna, and even for trans-oceanic telephone cables.

Polyethylene is only one of many plastics and chemicals that Union Carbide creates from oil and natural gas. By constant research into the basic elements of nature, the people of Union Carbide bring new and better products into your everyday life.

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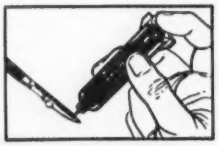

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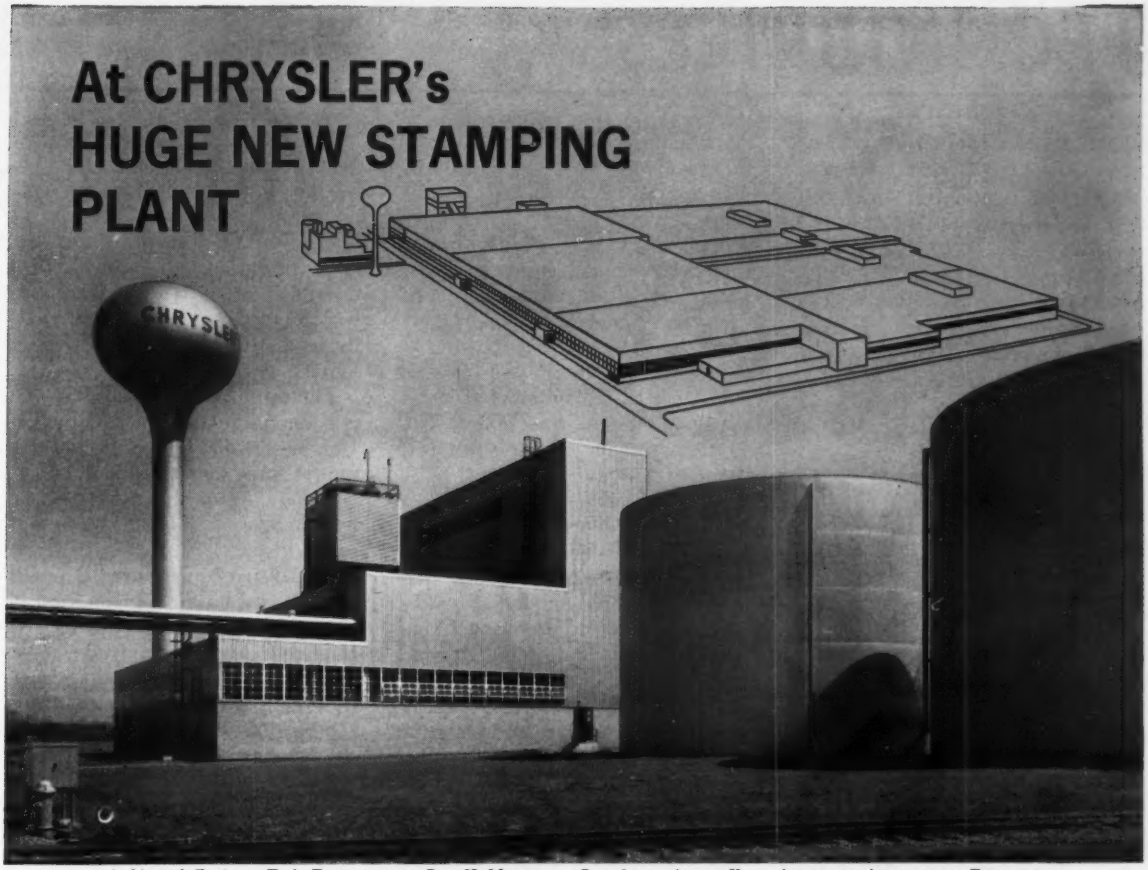

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TECHNIBRIEFS

Edited by D. J. Martin, ME '62

WORLD'S LONGEST CONVEYOR BELT HAULS LIMESTONE OVER 5 MILES

The world's longest permanent cross-country conveyor belt system was put in operation recently by the Ideal Cement Company. The 5½-mile system carries 1000 tons of crushed limestone per hour from the Company's Lawrence, Oklahoma quarry to its cement mill at Ada.

The new conveyor was engineered, fabricated, and erected by Link-Belt Company and consists of seven separate belt conveyors arranged consecutively to feed on to each other. The conveyor crosses two highways and the Frisco and Santa Fe railroads. Provision has also been made at numerous points for passage of cattle and farm equipment over the conveyor.

A single push button puts the entire 5½-mile system in operation. When the "start" button is pressed, the belt conveyor closest to the mill, the discharge end, starts immediately. After its tail pulley has reached about 50 per cent of normal operating speed, a relay starts the next conveyor in line. This in turn starts the one ahead of it, and so on, until the first conveyor at the quarry end is running at full speed. This starting sequence takes about five minutes when the system is fully loaded.

In a radical departure from steel-supported conveyors, the belts are supported by precast, prestressed concrete channel stringers spanning 50 feet. In addition to supporting the conveyor, the stringers form a cover over the top of the belt. One side of the conveyor is curtained by a continuous corrugated aluminum wind guard. The stringers rest on precast reinforced concrete U-stands.

NEW LENS FORMULA PROMISES COMPLETE COLOR CORRECTION

A "superchromat" lens, the first ever to be corrected for all colors of visible light, is promised by an improved optical formula devised by Dr. Max Herzberger of Kodak Research Laboratories.

The index of refraction of any glass varies slightly with the wavelength of the light used. In a camera, this effect, called chromatic aberration, causes the images of differently colored objects in the same position to fall at slightly different places on the film. Most common lens systems can correct for chromatic aberration for two colors, but the aberration still exists for the other colors of the spectrum.

Using special glasses called "short flints," it has been possible to correct some triple-element lenses for three colors. The use of fluorite in microscope lenses has been still more beneficial. But fluorite changes its refractive index with temperature and does not easily lend itself to long focal length lenses.

The application of the new dispersion formula developed by Dr. Herzberger allows the design of a unit of three lenses called a "superchromat." With this new type of lens, images of all colors are in perfect register.

The dispersion formula depends upon four data for a given kind of glass. Given these constants, refractive indices for any wavelength of light can be computed. Two of these data, plotted against each other, give the curve from which the glasses for a "superchromat" are chosen. If optical characteristics of any three glasses fall in a straight line on this graph, they will form a "superchromat" when correctly combined in a lens.

Kodak scientists have already designed telescope objectives with a "superchromat." They are now working on its use for corrected camera lenses and infrared optical systems.

Link-Belt

World's longest permanent cross-country transport belt conveyor system is now hauling 1,000 tons of crushed limestone per hour over a distance of 5½ miles. The system is elevated at several points to allow it to pass over highways and railroads.

AUTOMATIC TRANSISTOR PRODUCTION FORESEEN

Scientists at the Westinghouse research laboratories have taken a major step toward the fast, continuous, completely automatic manufacture of transistors and related semiconductor devices. Westinghouse scientists have constructed long ribbons of semiconductor devices by forming them along the surface of long, thin crystals of germanium about an eighth inch wide and a few thousandths of an inch thick. Such construction appears to be feasible for the automatic production of transistors and other solid state devices directly by machine.

These devices demonstrate the ultimate usefulness of a new method for growing germanium, a tech-

nique in which the germanium is grown as thin, flat continuous strips, or dendrites—the exact form in which it can be used directly in finished semiconductor devices.

Conventionally, germanium is grown as a thick, round ingot that requires costly, time-consuming processing to produce useful devices from it. In contrast, devices can be constructed directly on the smooth, mirror-like surfaces of germanium dendrites exactly as the material is grown. Germanium dendrites have only one preferred direction of growth, which causes them to form rapidly into strips about an .125 in. wide and a few thousandths of an inch thick. There is no known limit to their length.

Any desired number of devices can be built on a single dendrite to form a long, continuous strip of devices. Or, if desired, the individual devices can be separated from the group simply by cutting the dendrite into small pieces.

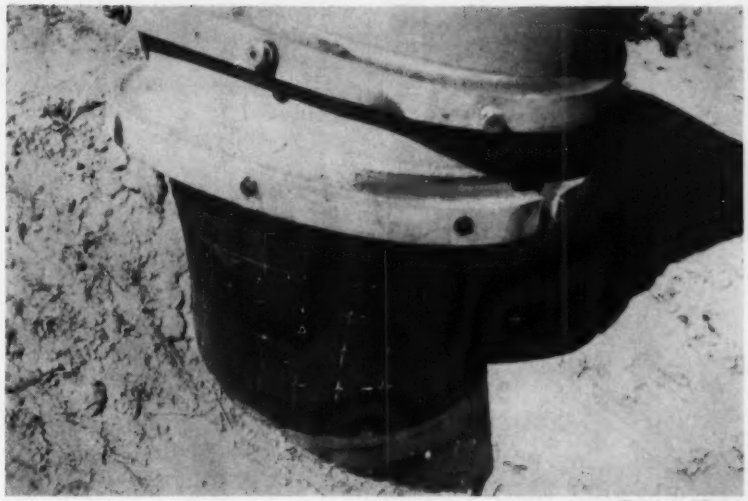
THERMOELECTRIC GENERATOR INCREASES OUTPUT TENFOLD

Westinghouse Corporation has developed a new thermoelectric generator capable of producing ten times as much power as any previously constructed.

Weighing 40 lb, the Westinghouse TAP-100 generator is not only the most powerful thermoelectric power plant ever devised, but, pound for pound, is the most efficient and compact device of its type for applications other than laboratory study. It delivers three times as much power per pound of weight as any previously announced generator, and it transfers into a comparatively large-scale device the advantages of thermoelectric power generation previously attained only in smaller units.

It operates on a gas flame at about 850 F. The generator converts the heat of the flame directly into electricity. Typical of thermoelectric devices, the power plant has no moving parts. Although the TAP-100 operates on butane fuel, it could easily be modified to use gasoline or kerosene. Westinghouse scientists are working on an advanced version which could be fired by nuclear fuel.

The thermoelectric generator is well-suited to military applications. Having no moving parts, it could operate in remote regions for months without human attention.



Emerson Electric

Thermo-lag coating in the Honest John rocket nozzle remains intact even after being subjected to deceleration loads of several thousand g's at impact. By subliming at constant temperature, the coating keeps the rocket surface thousands of degrees cooler than its surroundings.

PAINT COMPOUNDS CAN PROTECT MISSILES FROM INTENSE HEAT

Thermo-lag is the name given to a family of compounds that are applied like paint and reduce and control the temperature of materials or instruments subjected to intense heat. It works on a completely different principle from any other material currently in use for this purpose.

It dissipates heat by sublimating in the same manner that dry ice vaporizes. Sublimation is the name used to describe the phenomenon of evaporation of a solid directly into a gas. The phenomenon takes place at a certain temperature which remains steady regardless of the rate of heating encountered. With Thermo-lag, this temperature can be accurately predetermined over a wide range of values.

Consequently, Thermo-lag can be prepared not only to provide protection from heat, but to keep the temperature of the object being protected at a specified level. It can also be tailored to meet virtually any anticipated heat control condition.

"Although Thermo-lag has many commercial possibilities, it will be used primarily to keep the structures of missiles and space craft relatively cool while they are being exposed to a heat environment of thousands of degrees," according to the manufacturer.

"It additionally is a means of greatly reducing the weight of rocket motors, either by permitting the use of less metal or by making it practical to use lighter structural materials while maintaining the same structural strength."

REVERSIBLE TURBINES INCREASE NIAGARA POWER CAPACITY

The amount of power derived from Niagara Falls is regulated by a treaty with Canada which limits the amount of water that may be diverted from the falls. The varying needs of power in the Niagara region allow water available during the evening hours to go to waste while more water is needed to meet the demands during the day.

Engineers, trying to devise a plan to put the surplus water in the evening to use, decided to pump it out of the river and into a reservoir 85 ft above river level. To do this, they devised reversible pump turbines, that is, turbine generator sets that could be run backwards.

Normally, the turbine wheel is spun by water flowing past it and, in turn, spins a generator connected to it by a shaft. In the new units now being built, the process can be reversed by feeding spare electric power into the generator and using it as a motor. The motor, in turn, spins the turbine back-

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ward and causes the turbine to act as a pump, raising water to the reservoir.

As needed, this extra water can be allowed to run back downhill and generate power.

SUN'S RAYS CAN POWER AIR CONDITIONING

An experiment using the sun's heat to power air-conditioning units was described at the annual meeting of the American Society of Mechanical Engineers.

According to the authors of the paper, using sunshine to power an air-conditioning unit is a logical idea, since the hotter the sunshine, the more power it provides, and the more heat a solar air-conditioning system could remove. Thus, peak power output is provided when it is most needed.

The experimental unit they used works on much the same principle as a gas refrigerator, but the heat is supplied by the sun's rays, rather than by a gas flame. The somewhat involved process by which heat can be used for cooling is called "refrigeration by absorption" and relies on a mixture of water and ammonia gas which is alternately separated and remixed. In practice, heat from the sun would be gathered by a "flat plate collector," which could be installed near the building to be cooled. Such collectors are relatively simple and inexpensive.

NAVY USES UNDERWATER TV TO STUDY OCEAN BOTTOM

The operational use of underwater television equipment in deep water surveys has been announced by the Navy.

The television system, built for the Navy's Bureau of Ships, has been recently employed in successful ocean bottom surveys at depths of more than 600 ft. This was the first time that a continuous, remotely-controlled visual survey had been achieved at such depths.

Primarily designed for salvage and search operations, the vehicle is equipped with a closed circuit television system, an underwater lighting system, and a movable camera-housing capable of training 70 deg in any direction. The camera and its self-propelled unit are remotely controlled by means of a multi-conductor cable from a control vessel. The propulsion system enables the underwater vehicle to hover at any desired depth in currents and tides of several knots, assuring optimum use under varying conditions.

If fitted with suitable appendages, the vehicle could collect samples and specimens from the ocean floor and retrieve sunken objects.

FUTURE HOMES MAY FEATURE VERSATILE CLIP-ON WALLS

Inexpensive homes of the future may be built of prefabricated panels containing their own built-in insulation and utility and heating-cooling lines. The panels will be so light in weight that they could simply be clipped together in a matter of hours.

In fact, the panels might be so versatile and easily assembled, they would offer the homeowner the advantage of changing his room layout almost at will, with the basic exterior shape or design limited only by the dimensions and shape of the permanent house foundation.

The panels are built by pouring two or more chemicals into a space between two sheets of virtually any rigid material selected as outer surfaces of the panel. As they combine, these chemicals immediately begin producing a dense foam which fills the entire inner area of the panel. As the foam hardens, it becomes structurally rigid and strong, and also serves as an adhesive, bonding the surface "skin" tightly to the unit.

Plumbing and electrical lines may be molded right in the wall panels and be so designed that when the panels butt up against each other the connection automatically will be made. In this way, all utility lines will be ready for use as soon as the walls are assembled. And they will match up no matter how many times the walls are unclipped to change the house arrangement.

Where year-round air conditioning is desired, all windows can be molded permanently in place in the panels, providing a wall structure that is perfectly insulated. Since the wall panels could be standardized in size so that the style would be interchangeable, an old wall panel could be traded in for a new style if the owner grew tired of the original.

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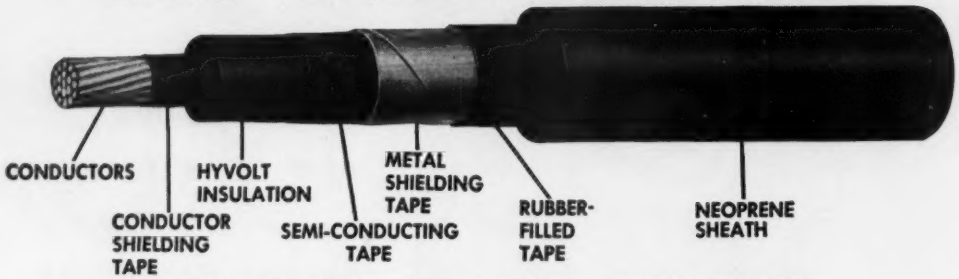

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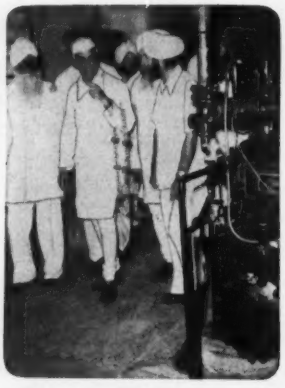

INDIA—Prime Minister Nehru inspects a Frick installation by Mohammed Singh, a Frick graduate.

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In the future, under the direction of the National Aeronautics and Space Administration, pioneering on the space frontier will advance at an accelerated rate.

The preliminary instrument explorations that have already been made only seem to define how much there is yet to be learned. During the next few years, payloads will become larger, trajectories will become more precise, and distances covered will become greater. Inspections will be made of the moon and the planets and of the vast distances of interplanetary space; hard and soft landings will be made in preparation for the time when man at last sets foot on new worlds.

In this program, the task of JPL is to gather new information for a better understanding of the World and Universe.

"We do these things because of the unquenchable curiosity of Man. The scientist is continually asking himself questions and then setting out to find the answers. In the course of getting these answers, he has provided practical benefits to man that have sometimes surprised even the scientist.

"Who can tell what we will find when we get to the planets? Who, at this present time, can predict what potential benefits to man exist in this enterprise? No one can say with any accuracy what we will find as we fly farther away from the earth, first with instruments, then with man. It seems to me that we are obligated to do these things, as human beings."

DR. W. H. PICKERING, *Director, JPL*

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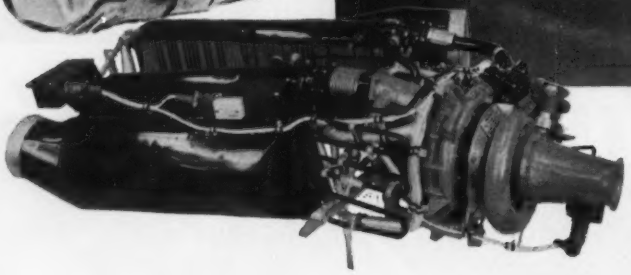
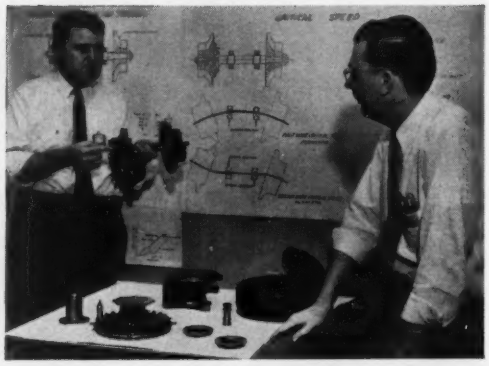
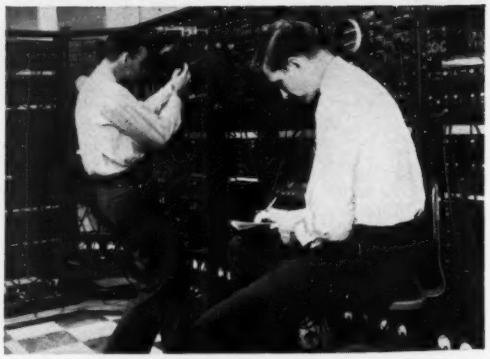
Student Frank G. pictures himself
on a typical Hamilton Standard

engineering assignment: environmental control system for Convair 880







ENGINEERING EXCELLENCE of Hamilton Standard equipment is reflected by the selection of its air conditioning and pressurization system for the new Convair 880 jet. Frank G. readily sees the variety of engineering applications involved and learns that he would, as an engineer, participate in its development in one of the following groups:

DESIGN ENGINEERING—Where the engineer, using technical skills in *aerodynamics, thermodynamics, heat transfer, vibration, servo mechanisms* and *electronics,* creates a working concept of the product to meet rigid specifications of performance, weight, size, reliability, cost and safety. Engineers shown at right are discussing stress analysis problems of the turbo compressor rotor system.

ANALYSIS ENGINEERING—Where the engineer, acting as a consultant in applied research, derives and evaluates data on *performance, structures, vibration* and *reliability.* In addition, Frank G. finds that close liaison is maintained with project and design engineers, who incorporate this information in the development of the product. Such machines as the Philbrick Analog Computer, shown at right, facilitate compilation of technical data.

PROJECT ENGINEERING—Where the engineer's prime responsibility is coordinating all activity from design through qualification testing. Frank G. discovers this means "shirt sleeve" work at laboratory test facilities, verifying product specifications with analysis and design groups, working with experimental technicians and contact with customers and vendors. Electronic temperature control pictured at right, was developed by our autonomous Broad Brook Electronics Department.

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FIFTY YEARS AGO IN THE ENGINEER

In most universities and colleges, the student is given, every term, a certain number of cuts for which he is held to no responsibility. He can simply absent himself from recitations, from lectures, from duty that belongs in the college course, and no one ever asks what he has done, or where he has gone. If that same young man absents himself once without a reasonable excuse, when he gets into business, he is usually hauled up and asked in the most impertinent manner, why he was away. No cuts in business, no talk about how many cuts a man has. The second or third time he does cut, he is discharged. Young college men work when they please, and as much as they please, the only restrictions being that they have to pass certain examinations. Their habits are left almost entirely to themselves. When they begin commercial life, those habits are regulated and rigidly prescribed by someone else.

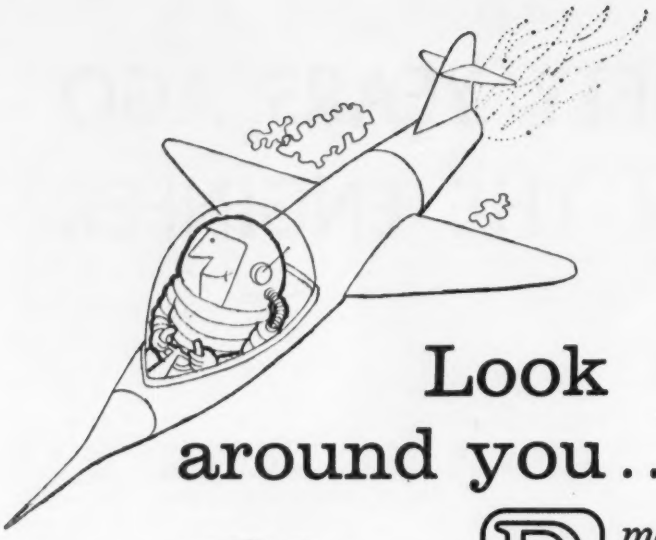
The central idea that the boy gets at college is training, training of the mind, storing the mind full of things. Now I say, without the slightest hesitation, that for success in life, intellectual training comes second or third. Without the slightest question, character comes first; good sense, second; and intellectual training third. The entire emphasis of the college life is on intellectual training. As long as the man commits no offense which sends him to jail, it is very little of the business of the management of those universities what those boys do.

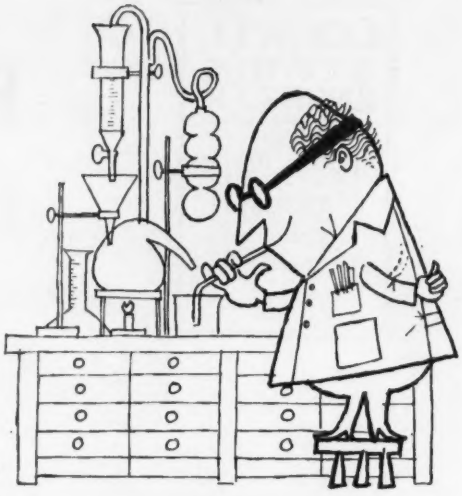
What is the remedy for these two faults? I do not believe there is any panacea for all faults, but I do believe that there is a great palliative possible. I believe that every young student in our colleges, from the student who intends to be a minister, on the one hand, to the mechanical engineer, on the other hand, should leave college at the end of the freshman year and spend at least one year in actual hard work in a shop of some kind. I say shop, because he will be certain to be under careful and constant supervision when working in a shop as a workman, alongside workmen. — *The Sibley Journal*, February, 1910.

A new process of animated color-photography was demonstrated in the concert hall of Madison Square Garden in New York City . . . Instead of using three color screens, red, green, and blue, in connection with two films, as does the inventor, the new process combines the blue and green into a single blue-green screen. The screens, of colored gelatine, are arranged so that each forms half of a revolving disk placed in front of the lens. The pictures are taken on a specially prepared film made panchromatic by means of suitable dyes. When this is projected through the colored screen, each picture of course being projected through the same colored screens as that through which it was taken, the spectator sees the view in its natural colors, since the eye retains the color impression of the red, for example, while the blue-green picture is being substituted for it and after the latter is in its place. In order to produce satisfactory results with this process it is necessary to run the machine twice as fast as the ordinary machine and project twice the number of pictures per second. This however improves the quality of the picture by slightly reducing the flicker. *The Sibley Journal*—January, 1910.

The commander of the Paris police force has perfected, for the use of the men in his command, spectacles, with the aid of which they may not only see very plainly what is going on ahead of them, but at the same time command a view of what is going on behind them, an arrangement that is expected to contribute materially to their efficiency. At the outer edge of these unique glasses, small, concave mirrors are attached. They are very "true" and so placed as not to interfere in the least with the forward view of the wearer. After brief preliminary use they are found to give excellent service— *The Sibley Journal*, February, 1910.

For a time, during the transition from steam to electricity, on the Southport Branch of the Lancashire & Yorkshire Railway, it was necessary to run steam trains between the electrical trains, at the same speed. This afforded an opportunity to compare the coal consumption of the locomotives with that of the powerhouse supplying the electric trains. It was found that the six-wheeled, coupled-tank engines consumed 80 pounds of coal per train mile for express trains, and 100 pounds for accomodation trains. The consumption of coal at the power-station for the electrical trains is 49 pounds per train mile. — *The Sibley Journal*, February, 1910.





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STRESS *and* STRAIN...

A meek little man walked into a barroom and ordered two drinks from the burly bartender. He drank one of the drinks and poured the other into his shirt pocket. After about ten rounds of this procedure the bartender says, "Pal, why are you pouring the other drink into your shirt pocket?" The little man jumped up into the bartender's face and snarled, "Mind your own business, you big bum, or I shall come over the counter and whale the fire out of you." About that time a blurry-eyed mouse stuck his head out of the pocket and said, "That goes for your damned cat, too."

• • •

Reader: "Do you make up these jokes yourself?"

Editor: "Yep, out of my head."

Reader: "You must be."

• • •

The ferocious lion ate a bull. Afterward he felt so wonderful he roared and roared. A hunter heard him roar and shot him.

Moral: When you are full of bull, you had better keep your mouth shut!

• • •

Horatio: "We're not making much money out of this amphitheatre."

Nero: "No, the lions are eating up all the prophets."

• • •

Definition of a hangover: When the brew of the night meets the cold of the day.

• • •

Little Jack Horner sat in a corner, crib notes under his eye. He opened his book and took a quick look, and now he's a Tau Beta Pi.

• • •

Papa Stork: "I surely had a busy day. I delivered 152 babies."

Mama Stork: "Yeah, me too. I delivered 145 babies."

Kid Stork: "Well, I can't deliver babies like you grownups can, but I did have fun today scaring hell out of a couple of high school kids."

• • •

LIFE OF A JOKE

1 minute: Freshman thinks of a joke and tells it one night to his girl friend.

1 day: Joke circulates through the women's dorm and a senior engineer overhears it.

1 week: Senior sends joke in to humor editor, claiming origination to himself. Humor editor thinks joke is miserable, but since deadline is only one day away and he is desperate for five more lines he decides to use it.

1 month: Joke appears at bottom of gag page. Humor editor is forced into exile.

1 year: Joke circulates through every engineering college magazine from Alabama to Canada, and from New York to Washington.

2 years: Gag writer for a radio program finds local college magazine on a bus and sees joke therein. Joke appears on next program. Gag writer loses union card.

2½ years: Reader's Digest prints joke from radio program.

4 years: College professor finally gets around to reading the issue of Reader's Digest and laughs heartily at joke.

5–30 years: College professor uses joke to start off his lectures at beginning of each term.

35 years: Joke passes on as does college professor.

• • •

"Whoever told that guy he was a prof? He just doesn't know how to teach the stuff. Everybody hates him. Everytime he tries to explain something he digresses so much that on one can understand what he's talking about. I thing he ought to quit teaching and go back to the farm."

"Yeah, I flunked, too."

• • •

The first sergeant, an Old Army monster, was chewing out the freshmen in formation, and writing all their names on his ram pad. "Now you fish," he snarled, "just to show you I mean business, I'm going to keep your names right next to my heart." With that he stuffed the ram pad into his hip pocket, and leered at them.

"Big-hearted S.O.B., ain't he," muttered some rear rank freshman.

• • •

I think that I shall never see
A girl refuse a meal that's free;
A girl with hungry eyes not fixed
Upon the drink that's being mixed;
A girl who doesn't like to wear
A lot of junk to match her hair;
But girls are loved by guys like me
'Cause I don't like to kiss a tree.

• • •

There are only two kinds of parking left on the campus—illegal and no.

• • •

A friend has described a pink elephant as a beast of bourbon.

• • •

"I will now illustrate what I have in mind," said the EE prof as he erased the blackboard.

• • •

A small boy leading a donkey passed a Marine camp. A couple of marines wanted to have some fun with the lad. "What are you holding on to your brother so tight for sonny?" said one of them.

"So he won't join the Marines," the youngster replied.

• • •

Thermometers—Something else graduated with degrees without having brains.

• • •

Doctor: "How's the engineering patient this morning?"

Nurse: "I think he's regaining consciousness. He tried to blow the foam off his medicine."

• • •

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the rest of the
magazine.

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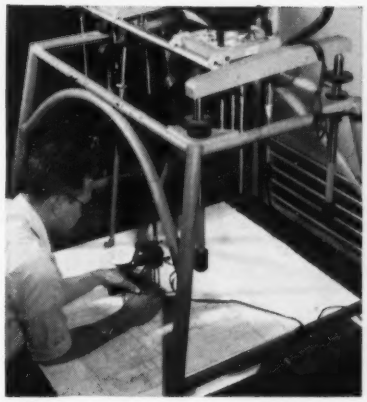

2 With this plotter, stereo aerial photos become contour maps, show highway routes, mineral-bearing formations, volume of coal piles.

3 Slides give the sales staff quick understanding of the engineering superiority of their product—equip them with facts for their customers.

4 Photographs of freight cars as loaded and as received provide information for engineers to develop better loading practices (as well as data for damage claims).

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One of a series

Interview with General Electric's Earl G. Abbott, Manager—Sales Training

Technical Training Programs at General Electric

UNIVERSITY MICROFILMS
313 N. FIRST ST.
ANN ARBOR, MICH

Q. Why does your company have training programs, Mr. Abbott?

A. Tomorrow's many positions of major responsibility will necessarily be filled by young men who have developed their potentials early in their careers. General Electric training programs simply help speed up this development process.

In addition, training programs provide graduates with the blocks of broad experience on which later success in a specialization can be built.

Furthermore, career opportunities and interests are brought into sharp focus after intensive working exposures to several fields. General Electric then gains the valuable contributions of men who have made early, well-considered decisions on career goals and who are confidently working toward those objectives.

Q. What kinds of technical training programs does your company conduct?

A. General Electric conducts a number of training programs. The G-E programs which attract the great majority of engineering graduates are Engineering and Science, Manufacturing, and Technical Marketing.

Q. How long does the Engineering and Science Program last?

A. That depends on which of several avenues you decide to take. Many graduates complete the training program during their first year with General Electric. Each Program member has three or four responsible work assignments at one or more of 61 different plant locations.

Some graduates elect to take the Advanced Engineering Program, supplementing their work assignments with challenging Company-conducted study courses which cover the application of engineering, science, and mathematics to industrial problems. If the Program member has an analytical bent coupled with a deep interest in mathematics and physics, he may continue through a second and third year of the Advanced Engineering Program.

Then there is the two-year Creative Engineering Program for those graduates who have completed their first-year assignments and who are interested in learning creative techniques for solving engineering problems.

Another avenue of training for the qualified graduate is the Honors Program, which enables a man to earn his Master's degree within three or four semesters at selected colleges and universities. The Company pays for his tuition and books, and his work schedule allows him to earn 75 percent of full salary while he is going to school. This program is similar to a research assistantship at a college or university.

Q. Just how will the Manufacturing Training Program help prepare me for a career in manufacturing?

A. The three-year Manufacturing Program consists of three orientation assignments and three development assignments in the areas of manufacturing engineering, quality control, materials management, plant engineering, and manufacturing operations. These assignments provide you with broad, fundamental manufacturing knowledge and with specialized knowledge in your particular field of interest.

The practical, on-the-job experience offered by this rotational program is supplemented by participation in a manufacturing studies curriculum covering all phases of manufacturing.

Q. What kind of training would I get on your Technical Marketing Program?

A. The one-year Technical Marketing Program is conducted for those graduates who want to use their engineering knowledge in dealing with customers. After completing orientation assignments in engineering, manufacturing, and marketing, the Program member may specialize in one of the four marketing areas: application engineering, headquarters marketing, sales engineering, or installation and service engineering.

In addition to on-the-job assignments, related courses of study help the Program member prepare for early assumption of major responsibility.

Q. How can I decide which training program I would like best, Mr. Abbott?

A. Well, selecting a training program is a decision which you alone can make. You made a similar decision when you selected your college major, and now you are focusing your interests only a little more sharply. The beauty of training programs is that they enable you to keep your career selection relatively broad until you have examined at first hand a number of specializations.

Furthermore, transfers from one General Electric training program to another are possible for the Program member whose interests clearly develop in one of the other fields.

Personalized Career Planning is General Electric's term for the selection, placement, and professional development of engineers and scientists. If you would like a Personalized Career Planning folder which describes in more detail the Company's training programs for technical graduates, write to Mr. Abbott at Section 959-13, General Electric Company, Schenectady 5, N. Y.

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